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The Open University

March 2008

uk resource
centre for women
in science, engineering
& technology

(In)visible Witnesses

Investigating Gendered Representations of Scientists, Technologists, Engineers and Mathematicians on UK Children's Television

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1 Introduction

Science education and mass media are two important sources where citizens are exposed to representations of science, technology, engineering and mathematics (STEM). It follows that the images of STEM citizens witness via engagement in science education and mass media are likely to (at least partly) influence how they subsequently perceive these subjects and those who work in STEM. Witnessing the relative (in)visibility of women working in STEM may therefore lead to perceptions of STEM as a gendered (read male dominated) profession.

A recent research review into the participation of girls in physics in the classroom (Murphy and Whitelegg, 2006) synthesised the evidence from over 15 years' worth of research into this topic and described the multi-faceted nature of the issue for girls' participation in physics, and within science more generally. The review revealed that one of the key factors determining students' attitudes to physics relates to students' self-concept—how students see themselves in relation to the subject both now and in the future (ibid). The development of self-concept is closely linked to development of identity.

The development of an identity as a scientist, technologist, engineer or mathematician affects educational subject choices which can subsequently open up career opportunities (whilst potentially closing down others) that can lead to enhanced life chances and improved salary prospects. Girls' lower participation in STEM subjects, particularly physics, beginning at school and transmitted down the educational and employment pipeline, is well documented (Rees, 2001; Murphy and Whitelegg, 2006). Therefore girls are potentially losing out on pathways to better-paid career opportunities by not choosing to study STEM at school. It follows that the UK economy may also be disadvantaged in the future because employers are recruiting from a smaller pool of (mainly male) candidates from which to select the nation's future scientists, technologists, engineers and mathematicians. The STEM workforce is therefore likely to remain unbalanced in terms of its overall gender distribution, in favour of males, and so be lacking in diversity. It follows that authentic representations of the STEM workforce are also likely to (re)construct a gendered image of a largely male-dominated profession.

If representations of physics and STEM that children and young people encounter in their lives influence their development of self concept and identity in relation to STEM, then this in turn may be another factor affecting their ongoing engagement and participation with these subjects. Hence, exposure to sex-role stereotypes of scientists (and technologists, engineers and mathematicians) in media portrayals can be another factor that influences the formation of gendered identities (Long *et al*., 2001; Steinke *et al*., 2007).

There is some evidence (e.g. see Women and Work Commission, 2006; Semta, 2005) which suggests that images of women scientists shown in television programmes portraying 'forensic science', such as Professor Sam Ryan in the BBC drama *Silent Witness*,[2] may be having positive effects on course and career choices for a small number of undergraduate (8%) and Masters (15%) students (Semta, 2005).

Of course, this evidence assumes a simplistic "cause and effect" relationship between television viewing of gendered role models and course/career choice. To be more confident about the influence of gendered portrayals of STEM on UK television requires a more systematic approach.

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[2] See http://www.bbc.co.uk/drama/silentwitness/.

With this context in mind, the principle aims of the (In)visible Witnesses Project[3] were to:

1) Study the (re)construction of gendered representations of STEM on UK television, i.e. to investigate the continuing portrayal of established stereotypes of STEM and document the emergence of new images.
2) Investigate the extent to which these images might affect children and young people's perceptions of STEM.

Alongside the work of a complementary project conducted at Cardiff University,[4] the overall aim for this project is for the findings and recommendations to inform the future production of television programmes that feature STEM.

1.1 Background to the project

Mass media are fundamental sources for informing 'citizen-consumers' about a wide range of issues, and have an important role in (re)constructing meaning over time (Kitzinger, 2000). It follows that mass media have the potential to (re)construct stereotypically gendered images of STEM over time (Steinke *et al.*, 2007), also to contribute to the construction of new stereotypes of scientists, technologists, engineers and mathematicians. Following from these premises, it can be argued that consistently gendered mass mediated portrayals of STEM may partly influence how children and young people perceive STEM, alongside perceptions of whether a STEM-related career is attractive and achievable. Furthermore, stereotypes that portray women as successful STEM practitioners also have the potential to have a positive influence on girls and young women's perceptions of STEM.

This report is concerned with Phases 1 and 2 of the (In)visible Witnesses project. The research questions relating to these phases are:

1. How much STEM is represented on UK terrestrial TV; what is the breakdown in terms of these individual subject areas? (Phase 1);
2. Which genre/type of programme represents the most STEM; what is the distribution of words spoken by women and men in extracts that portray STEM? (Phase 1);
3. What are children and young people's current perceptions of STEM; are these affected by stereotypical images of STEM in programmes for children and young people on TV; if so, how; are these perceptions influenced by the age of the participants? (Phase 2).

1.2 Investigating perceptions of STEM

The findings from 'Draw-a-scientist' activities conducted in the early 1980s (e.g. Chambers, 1983) showed that the dominant stereotypical view of a scientist held by children and young people was consistent with earlier work conducted in the late 1950s where high school students were invited to write essays about scientists (Mead and

[3] (In)visible Witnesses is an Open University-led (OU) project, which began in autumn 2005. The project team has presented papers at a number of conferences, seminars and workshops; see Appendix I for further details.

[4] Professor Jenny Kitzinger and her colleagues at Cardiff University are running a complementary project, which is also funded by the UKRC (copies of the reports can be obtained from the UKRC: info@ukrc4setwomen.org). We are grateful to them for their helpful comments on an earlier draft of this report.

Métraux, 1957).[5] The dominant view was still that of an elderly white male with unruly white hair, wearing a white lab coat and glasses; the enduring image of Albert Einstein.

However, there are some more recent indications to suggest that new stereotypes featuring women scientists are emerging in mass media representations. For example, Flicker (2003, p. 316) suggests in discussing feature films that:

"The woman scientist tends to differ greatly from her male colleagues in her outer appearance: she is remarkably beautiful and compared with her qualifications unbelievably young. She had a model's body - thin athletic, perfect, is dressed provocatively and is sometimes "distorted" by wearing glasses."

Given this evidence of newly emerging (if unachievable for many) images of women scientists it is therefore interesting to note that in a more recent implementation of the 'Draw-a-scientist' activities (Frayling, 2005; Frayling, 2006), approximately half the girls who participated drew female scientists which marked an increase from 1.4% in Chambers' study conducted over 20 years ago. According to Frayling:

"*This may relate to cartoons produced in America and Japan featuring a feisty action-girl as a member of the intrepid team. Or to Hollywood films such as 'Contact', with female scientist-heroes. In the nineties, quite a few young and beautiful scientists appeared on the big screen. Unlike their male counterparts, they had terrific hair which they had to shake out; they were usually in their twenties (but already a "leader in her field"); and if they wore glasses, they removed them for much of the film."* (Frayling, 2006, p.27)

These findings are consistent with other recent 'Draw-a-scientist' studies that also record greater numbers of girls and young women drawing female scientists (e.g. see Steinke *et al*., 2007; Rodari, 2007).

So new sorts of gendered images of scientists, technologists, engineers and mathematicians are becoming available to children and young people via mass media, alongside evidence to suggest that perceptions of STEM may also be changing. But how often are these new portrayals available compared to the well established stereotypical images described above; do the new portrayals present authentic role models that are useful for girls (and boys); and are they believable (and believed to be achievable) as images of STEM professionals by children and young people? Do they show another unrealistic stereotypical image that fails to adequately represent what it means to be an authentic scientist, technologist, engineer or mathematician in the 21st Century? Will they have a positive effect on young people's self-concept, particularly in terms of gender, potentially increasing recruitment of girls and young women to STEM courses and careers?

[5] In Mead and Métraux's (1957, p. 385) study participants were given one of three questions to complete by writing between a paragraph and a page's-worth of prose. Notably male participants in this study were asked to write about what kind of scientist they would (not) want to be; female participants were asked to write about what kind of scientist they would want (not) to be, *or* what kind of scientist they would (not) like to marry.

2 Methodology

We start from the methodological premise that there are three elements of mass communication, production, content and reception that are inextricably linked in a dynamic, organic and continuous cycle (Philo, 1999). For the purpose of media research these elements can be delineated and subjected to systematic and detailed analysis (Thompson, 1999; 1988). In this project we have studied two of these elements in detail, content and reception through an analysis of media content (television) and a reception study (involving children and young people).

2.1 Analysis of media content (Phase 1)

We have collected and analysed a range of genres in two one-week samples, focusing on programmes for children and young people and using content analysis. This is defined as:

"[...] an accepted method of textual investigation, particularly in the field of mass communications. It involves establishing categories and then counting the number of instances when those categories are used in a particular item of text, for instance in a newspaper report." (Silverman, 1993 p. 59)

During the two sample weeks we recorded all the programmes that we could identify from TV listings as having some STEM content, also including all news and current affairs programmes and programmes broadcast in schedules identified as being for children and young people (e.g. CBBC, CITV, programmes for schools). Following this we identified the extracts from programmes that contained STEM content and produced a sub-set of extracts broadcast during scheduled slots for children and young people, the focus of our study. This sub-set was further sub-divided for detailed analysis into types of programmes (cartoons and animations; news and current affairs; educational; pre-school; and other). Using content analysis we catalogued in detail the participation and roles of the various participants in these extracts. We then produced qualitative narrative summaries of each extract noting the critical incidents from a gender perspective.

2.1.1 Data collection and analysis

In phase 1 of the project we recorded a selection of programmes from the five terrestrial television channels broadcasting using analogue signals (i.e. BBC1, BBC2, ITV1, Channel 4 and Channel 5) in two 'snapshot' weeks. Table 1 shows the audience share for these channels for the two one-week sample periods.

Table 1: Audience share for the five channels in the two week-long samples. (Broadcasters' Audience Research Board (BARB) Ltd)[6]

Channel	Audience Share (%) Sample 1 Week ending 12 October 2005	Audience Share (%) Sample 2 Week ending 19 March 2006
BBC1	24.5	23.2
BBC2	8.8	9.8
ITV1	21.5	20.4
Channel 4	8.9	9.2
Channel 5	6.6	6.3
Sub total	**70.3**	**68.9**
Others[7]	29.7	31.1

The two samples ran for seven days each and were six months apart - from 6 to 12 October 2005, inclusive and 10 to 19 March 2006, inclusive. The two samples include examples of breakfast, daytime, children's, primetime and late evening television and of factual and fictional programming, including: news reporting, documentaries, schools programmes, cartoons, situation comedies, game shows and dramas.

In Sample 1 (week ending 12 October 2005) 302 programmes were recorded, resulting in just over 162 hours of recorded television. In sample 2 (week ending 19 March 2006)[8] 364 programmes were recorded, resulting on 211 hours and 50 minutes of recorded television.

In total we recorded 666 programmes and a total of 373 hours 55 minutes of programming over the two samples; about 22% of the available programmes (Table 2).[9] (We note that the BBC shifted its children's programmes – broadcast simultaneously as the digital channels CBeebies and CBBC - from BBC1 to BBC2 between the two sample periods. This accounts for the differences between these channels in sample 1 and 2.)

[6] These figures include those viewers who chose to watch these channels through satellite, cable and freeview. This is because BBC1, BBC2, ITV1, Channel 4 and Channel 5 were broadcast using both analogue and digital signals during the sample periods.

[7] The category "others" includes channels that are only available to viewers through satellite, cable and freeview.

[8] This was National Science and Engineering Week - see http://www.the-ba.net/the-ba/Events/NSEW/index.html.

[9] 11 programmes - six broadcast for young children and five evening news bulletins – were not included in the final sample, either because the video recording equipment failed, or because previous scheduled programmes overran. However, we note that none of these programmes were described in the television listings as specifically including STEM content.

Table 2: Programmes recorded from the five channels in the two week-long samples.

	BBC1	BBC2	ITV1	Channel 4	Channel 5	Total
Sample 1 No. of programmes	61	64	60	48	69	**302**
Sample 1 Duration hrs/mins[10]	36/30	35/00	30/35	28/35	31/25	**162/05**
Sample 2 No. of programmes	49	114	57	50	94	**364**
Sample 2 Duration hrs/mins	29/05	64/00	29/50	39/55	49/00	**211/50**

To inform the pre-selection process we investigated the television listings for programmes that might include STEM content, e.g. the BBC2 science documentary programme *Horizon*. We also recorded programmes where descriptions were inconclusive but where STEM content might be reasonably expected to be broadcast, e.g. news and current affairs programmes and game shows. Finally, we recorded programmes where the television listings did not provide detailed information and where the research team was unsure of the specific content, e.g. programmes broadcast in scheduled slots for children and young people. Overall, therefore, our sample should be considered representative of the types of STEM programmes broadcast using analogue signals in the UK during the sample periods.

Once collected, the programmes in the two week-long samples were analysed to confirm whether they included STEM content, with a view to conducting further detailed quantitative and qualitative analysis. To achieve this further selection we employed the following operational definitions of science, engineering and technology. These definitions were adapted from earlier work (The ENSCOT Team; Holliman, Trench *et al.*, 2002).

Science — These programmes should include significant explicit scientific content, namely a reference or references to scientific findings, scientific research, scientific procedure, science as an intellectual activity, or scientists.

Technology — These programmes should include significant explicit technology content, namely a reference or references to technological design, technology research, technological procedures, technology as an intellectual activity, or technologists.

Engineering — These programmes should include significant explicit engineering content, namely a reference or references to engineering design, engineering research, engineering procedures, engineering as an intellectual activity, or engineers.

Mathematics — These programmes should include significant explicit mathematical content, namely a reference or references to mathematical concepts and formula, mathematics research, mathematics as an intellectual activity, or

[10] Rounded to nearest 5 minutes.

mathematicians.

Following an initial period where these operational definitions were discussed by the project team, researchers viewed each of the programmes recorded for the two samples, selecting those with STEM content according to the definitions listed above, and entering the details of these programmes into a database, recording the: channel, name of the programme, when it was broadcast, whether it portrayed science, technology, engineering or mathematics, and the type of programme (e.g. whether it was news and current affairs, pre-school, learning/educational, cartoons and animations or other). The STEM extracts were also re-recorded for further quantitative and qualitative analyses.

In conducting our initial analyses we have used a flexible unit of analysis, which we have called an extract. We define an extract as ranging from complete a programme where this was deemed to contain STEM content its entirety (e.g. BBC's *Horizon*) through to discreet news items within a bulletin. Adopting this flexible unit of analysis allowed us to code individual STEM extracts within the same news bulletin, but also to record an entire programme. However, we note that the figures produced in terms of the number of extracts mask the possible differences in length of the extract. These figures should therefore be treated with some caution. (To address this issue, we conducted a more detailed analysis of the speaking actors, see below.)

The same definitions of STEM were applied to factual and fictional representations, and to adults, children and non-humans. Hence, the same operationalised definitions were applied to cartoon characters, children's characters and scientists portrayed in factual programmes, such as news and current affairs.

We note that there are challenges in deciding what counts as STEM, e.g. when programmes examine areas such as biomedicine, architecture, and/or information and communications technology. This was also the case when a programme was aimed at pre-school children, where defining what counted as STEM was often harder to judge because STEM professionals were largely absent, and the techniques and/or concepts being portrayed were more simplistic. When the researchers were unsure about whether to select a programme, or programme extract as STEM, this was viewed and discussed with the project team so that a consistent application of the operational definitions could be maintained.

Once the initial selection of extracts that portrayed STEM was completed, we conducted a quantitative analysis of the overall sample. We used these data to produce a further sub-set of STEM content for further analysis, focusing on extracts broadcast within specific schedules for children and young people, e.g. programmes broadcast as part of CBeebies, CBBC, CITV, Channel 4 Learning, or Channel 5's *Milkshake!*[11]

To inform the analysis of televisual content for this sub-set of extracts, fully annotated transcripts (Hansen, *et al*., 1998) were produced. Initially, this involved the production of verbatim transcripts. These were checked for accuracy and coded for all recorded speech using the analytical concept of a speaking actor.

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[11] We note that this sub-set of programmes does not include all the programmes that children and young people might have access to. For example, we have not included programmes broadcast during primetime, or those broadcast on digital-only channels. In part, we aim to address this limitation in Phase 3 of the study.

For the purposes of our analysis 'speaking actors' were defined as any actor making an audible utterance or utterances that could be recognised as belonging to a known language or dialect. Actors were defined as those off-screen (e.g. narrators) and on-screen who made a speaking contribution. This included humans, including cartoon characters, and non-humans (e.g. anthropomorphised animals).

The speaking actors were coded in terms of gender—female, male, mixed and unidentified[12]—and the role of the actor—e.g. narrator, presenter, scientist, etc., and cross-referenced with the number of words spoken by each one. These data have been quantified to produce overall figures for the data set, then sub-categorized firstly as Sample 1 or 2, and secondly by type of programme.

Further to this, we have produced narrative summaries of these extracts, conducting inductive coding to investigate emerging themes, e.g. about the nature of science, as well as comparing our findings from the quantitative data with the overall theme of the extract, programme, series and/or type of programme, the ways characters have been portrayed in previous episodes, the relationships between speaking actors, etc. These narrative summaries will be explored in more detail in the later stages of the project, and so are not discussed in length in this report.

The results of the analyses of media content are presented in Section 3.1.

2.2 Goals of the Reception study (Phase 2)

In phase 2 of the project we investigated how television portrayals might influence young viewers' perceptions of STEM, and whether they have the potential to influence future course and career choice. Embedded in this phase of the project is the concept of agency. From the perspective of the active mind, what the viewer already knows about STEM, or rather the culture and processes of these practices and of the practitioners, influences what happens within and outside the classroom. These informal and formal learning experiences are likely to influence what the viewer takes notice of in the programme (or lesson). Whether citizens accept or reject the image of STEM presented in the programme (or lesson) will be affected by their pre-existing feelings, attitudes, experiences and understanding of STEM. This indicates that mass media influences, particularly those encountered at a very young age can have an important role in shaping girls' and boys' identity, their understanding of STEM, and other factors that influence their engagement with STEM.

In phase 2 we worked with two class-sized groups of children and young people at Key Stages 2, 3 and 4 (ages 8 to 15 years). A simplified overview of the procedure for the reception study is shown in Table 3 below—see also the more detailed explanation of the procedure in Appendix II. (Appendix II includes a description of the activities completed as part of the carousel.[13])

Participants were informed that they were participating in a research study and that none of the activities should be considered to be a "test".

[12] The category 'mixed' includes groups of speaking actors, e.g. a group of children (mixed gender) singing. The category 'unidentified' includes speaking actors that could not be categorised as female, male or mixed, e.g. anthropomorphised 'gender neutrals' creatures, such as *The Hoobs*. Where it wasn't clear from the extract itself whether a speaking actor was female or male, we have conducted web searches to try to confirm the gender.

[13] A carousel is a term familiar to schoolteachers. We have used the term carousel to define a series of data collection activities, each of which requiring participants to address an issue related to children's STEM television programmes. Participants were given the same amount of time for each activity, moving in small groups from one to the other. These activities were not designed to be completed sequentially and there was no competitive motive for completing them.

Table 3: Illustrating the simplified structure of the procedure for Phase 2

Stage	Activity
1	Initial questionnaire (see Appendix III). Self-completed as individuals.
2	Draw-a-scientist activity. Full group activity, self-completed as individuals.
3	Carousel. Small group activity. Six tables, four featuring still images as worksheets (see Appendix II and V). Two tables viewed extracts—see Stage 4.
4	Viewing of extracts from the sample. Follow-up worksheets (see Appendix II).
5	Story-board. Prepared in small groups, then presented to the whole group (see Appendix II).
6	Reflective writing. Individual activity. Participants asked to imagine themselves as scientists.
7	Evaluation[14]. Individual participant reflection on the activities in Stages 1 to 5.

We note that the procedure was adapted for the two class-sized groups of participants for four main reasons:

1. We adapted the activities after the first group to ensure that they worked as effectively as possible.
2. The Key Stage 2 participants were working within a classroom setting and we needed to adapt the procedure to meet the needs of the teaching staff and national curriculum. This contrasted with the older group of participants who worked out of term time and were therefore more flexible in terms of (a relative lack of) time and/or curriculum constraints.
3. The Key Stage 2 participants completed the tasks in stages, over a greater period of time. For example, they completed the questionnaire approximately one week prior to Stages 2 to 5, completing Stage 6 approximately one week after this.
4. We adapted the examples used for the carousel and viewing of extracts (Stages 3 and 4 respectively) to match the age range of the participants.

Working within a classroom scenario we began by eliciting their current images of STEM firstly via a questionnaire and also using the 'draw-a-scientist' activity (Chambers, 1983; Frayling, 2006; Steinke *et al.*, 2007; Rodari, 2007).

This was followed by a carousel activity where participants were shown a range of still images from popular TV programmes and some video extracts from our STEM sample. We asked participants to identify the scientist(s)[15], the scientific activities[16], their opinions of the participants they have identified, and the context of the 'action'.

Participants were then asked to discuss and then construct a story and/or some dialogue based on their chosen image(s). We focused on small groups of participants during this activity and recorded their discussion on digital audio recorders, which we then used alongside the products (plans given in a series of drawings) to inform our analysis.

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[14] The KS2 group did not undertake the evaluation.
[15] The use of 'scientist' here is meant to also include engineers, technologists and mathematicians.
[16] Similarly 'scientific activity' includes engineering, etc.

As a follow-up activity participants undertook some reflective writing where they were asked to imagine themselves as adult scientists in the future (similar to the method described by Mead and Métraux, 1957).

Finally, we asked students to complete an evaluation of the day's activities.

The results of the reception study are presented in Section 3.2. They include the results of the initial questionnaire which was coded on a question-by-question basis. Wherever possible we have included relevant examples of participants' answers to these questions.

The data collected from the draw-a-scientist activity were coded following Chambers (1983) protocol which uses a scale of 1 to 7. This protocol gives one point for each of the following:

1 laboratory coat

2 spectacles (including protective goggles)

3 facial hair (itself a gendered code)

4 symbol of research - scientific instruments and/or laboratory equipment

5 symbols of knowledge (e.g. books, laboratory notebooks and filing cabinets)

6 technology: 'products' of science (e.g. test tubes, explosions)

7 relevant captions, formulas, equations.

To ensure consistency in coding, the data were discussed by all members of the research team. As part of this process the team also noted that the Chambers (1983) protocol failed to take account of what we considered to be important and relevant symbolic codes. We therefore included the following additional codes: gender of the scientist; full figure or head only; type of scientist; if the hairstyle was 'mad'; and noted the name the children gave their scientist.

Stages 3, 4 and 5 were recorded digitally for analysis. Wherever possible we have also collected data from participant responses to activities, e.g. answers to the carousel, the plans for the storyboard activity and responses to the reflective writing activity. These data were coded, following an inductive or 'grounded' approach (Glaser and Strauss, 2001; Strauss and Corbin, 1990; Strauss, 1987).

3 Results and interpretations

In this section we present relevant results and interpretations from the analysis of media content and the reception study. This section is split into two main sub-sections, documenting results from the analysis of media content and the reception study.

3.1 The analysis of media content

The results of the analysis of media content are split into three sub-sections: overview of Samples 1 and 2; quantitative distribution of speaking actors; and interpreting the quantitative findings from the analysis of media content.

3.1.1 Overview of Samples 1 and 2

In Section 2.1 we described our approach to investigating media content, noting that we used the same methods for our analysis of Samples 1 and 2. This facilitates comparison between the two week-long samples, allowing us to look for similarities and differences over this six-month period. Such an approach encourages a greater (but far from complete) measure of confidence in the subsequent findings.

Of the 302 programmes recorded for Sample 1, 156 extracts were coded as containing some STEM content; 57 of these were coded as children and young people (Table 4). For sample 2, of the 364 programmes recorded, 247 extracts were coded as containing some STEM content and 97 of these coded as children and young people's programmes.

Table 4: Breakdown of STEM content from sample 1 (*n*=156) and sample 2 (*n*=247), & for the sub-set: children & young people (sample 1 *n*=57; sample 2 *n*=97)

	Sample 1	**Sample 1 Children & young people**	**Sample 2**	**Sample 2 Children & young people**
Science	114	32	160	42
Technology	13	7	50	31
Engineering	23	16	23	12
Mathematics	6	2	14	12
Total	**156**	**57**	**247**	**97**

Table 4 also shows the breakdown of programmes coded as science, technology, engineering and mathematics. Science clearly dominates this distribution in both samples (73% and 65% respectively) and the sub-set for children and young people (56% and 43%).

In the combined sample there was more science than other disciplines (technology, engineering and mathematics) as shown by Figure 1.

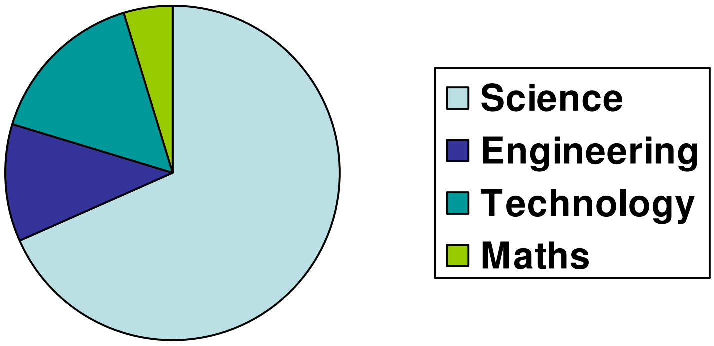

Figure 1: Proportion of science, engineering, technology and maths programmes shown on the 5 terrestrial channels in the two sample weeks

3.1.2 Quantitative distribution of speaking actors

Having viewed all the extracts and also using the transcripts of each extract we have broken down the speaking actors, in terms of the number of words spoken in each extract, by gender and type of programme. These findings are also categorized as Sample 1, Sample 2 and the combined results of the two samples.

Table 5 shows a clear emphasis in the overall distribution of words spoken in the combined sample in favour of males (66% males to 31% females). A more complex gender distribution of spoken actors can be identified, however, by investigating the differences between the types of programmes, also between the two sample distributions.

In the category cartoons and animations, for example, the distribution is clearly in favour of males across the two samples (84% and 66% male, respectively). This contrasts with news and current affairs where the distribution is clearly in favour of males in sample 1 (64% male), but shows a greater proportion of females in sample 2 (58% female).

To a certain extent this pattern can also be identified in the educational programmes where the distribution in sample 1 (87% male) is skewed heavily towards males and much less so in sample 2 (53% male to 47% female).

The category ‘pre-school’ also features more males proportionally than females in both sample periods, but also features some ‘mixed’ speakers—mainly children singing in groups, and unidentified speaking actors, mainly characters that are deliberately gender neutral.

Table 5: Breakdown by gender for each type of programme for samples 1 and 2[17]

	Sample 1 %				Sample 2 %				Combined %			
Type of programme	Male	Female	Mixed	Unidentified	Male	Female	Mixed	Unidentified	Male	Female	Mixed	Unidentified
News and current affairs	64	37	0	0	42	58	0	0	52	48	0	0
Cartoons and animations	84	15	0	0	66	32	1	2	72	26	1	1
Educational	87	13	0	0	53	47	0	0	70	30	0	0
Pre-school	47	35	18	0	57	31	2	10	55	32	6	7
Other	54	45	1	0	59	36	0	2	58	38	0	1
Total	80	19	1	0	57	40	0	2	66	31	1	1

[17] Figures rounded to the nearest whole number.

3.1.3 *Interpreting the findings from the quantitative analysis of media content*

The analysis that is included in this sub-section serves as an illustrative example of the iterative approach that is being adopted to the quantitative and qualitative data analysis, also how we intend to 'cross-reference' the results from the content and reception studies.

The distribution of speaking actors in the news and current affairs extracts would appear to be more balanced than in the other types of programmes. Further analysis of the annotated transcripts, however, reveals a more complex pattern. The speaking roles in these extracts are almost exclusively newsreaders and reporters in the case of CBBC's *Newsround*, and presenters in the case of CBBC's *Blue Peter*. Scientists appear in only three of the extracts, and all of these scientists were male:

- *Newsround* (6 October 2005): Professor Huosheng Hu briefly discusses his invention - a robot fish - and its potential for use as a piece of military technology.
- *Newsround* (10 March 2006): Mathew Genge from Imperial College describes the role of the Mars orbiter in the NASA space mission due to reach the planet later that day.
- *Blue Peter* (15 March 2006): Female presenter interviews Dr Ahmed Nahoum, Director of the Brook Hospital for Animals in Egypt. Dr Ahmed describes the role of mobile clinics in treating working animals in rural areas of the country.

Images from *Blue Peter* and *Newsround* were included in the reception study carousel activities (see Appendix II, Stage 3). Both KS2 and KS3/4 groups appeared to recognise the particular role of the presenters, newsreaders and reports in relation to the STEM content of the programming. Questions about whether the programme contained any STEM content, for example, elicited the comments below:

- 'It includes engineering because they show what people have invented'.
  (Group 1.6: *Newsround*)
- 'Yes, when it is in the news it is described relatively simply'.
  (Group 2.2: *Newsround*)
- 'Yes. It is news so maybe reports on some stuff'.
  (Group 2.3: *Newsround*)
- 'Yes but only if it's on the script'.
  (Group 2.2: *Blue Peter*)
- 'Yes. Have guests'
  (Group 2.3: *Blue Peter*)

Similarly, when asked about the characters, in this instances the presenters, newsreaders and reporters, and whether they talked about STEM, responses included:

- 'They talk about news that comes from around the world'.
  (Group 1.5: *Newsround*)
- 'They talk about them if it's in the news.'
  (Group 2.1: *Newsround*)
- 'Talk about it if they have a guest. Go to an engineering place to see how it works'.
  (Group 2.4: *Blue Peter*)

Recordings made of the participants discussing these programmes also illustrate how the participants sought to make the distinction between 'doing science' and 'talking about science'. So, whilst the news and current affairs extracts might appear to represent examples of 'good practice' in that the distribution of speaking actors is relatively balanced between genders, whether they have a positive affect on children's self-concept in STEM requires further analysis of what children think it means to present/practice STEM.

Another example of the way in which our approach is facilitating a more in-depth analysis can be demonstrated by looking at an aspect of the report about Professor Huosheng Hu's invention of the robot fish (*Newsround* 6th October 2005). In the extract, two children are interviewed, and they describe the robot fish thus:

Male - child	I think that this is very hard to make, because you have to need all the circuits and the wires and the batteries together to make a circuit, and because they're not like normal fish.
Female - child	I think these fish are prettier than normal fish because they have nice scales, and they are shiny, and their eyes are big.

Notably, the male child discusses how the fish have been made, whilst the female child talks about how attractive the fish look. As such, they could be said to be (re)constructing gendered patterns of behaviour, dependent on how one defines gendered patterns of behaviour. However, we have no data to indicate how this extract was produced and so it is difficult to determine what the children were asked, or whether they answered several questions of which these are selected quotations.

Once again, a focus on the broader patterns illustrated by the quantitative data may disguise the gendered nature of these representations. Our further work on the narrative summaries of the extracts will allow us to investigate evidence of consistent patterns of gendered behaviour across the two samples and different types of programmes. These findings, combined with further insights offered by the reception study, will enable us to unpack these issues further.

3.2 The reception study

The results of the reception study are split into seven sub-sections; overview of the reception study; initial questionnaire; draw-a-scientist activity; carousel activities; narrative summaries of the storyboard activity; reflective writing activity; and evaluation activity.

3.2.1 Overview of the reception study sample

Table 6 illustrates the overall sample for the reception study, listing the gender distribution, date of the group, location, and the choice of programme for the storyboard activity (see Section 3.2.5 for more detailed discussion).

Table 6 shows that 45 participants were involved in the reception study of which 25 were female and 15 were male. The two data collection dates were 19 June 2007 and 25 July 2007.

Table 6: Illustrating the Group ID, gender distribution, age range, storyboard programme

Group ID	Gender	Age range	Storyboard
1.1	Mixed (4)	8 to 10	Cartoon: science drama/comedy
1.2	Mixed (4)	8 to 10	Cartoon: factual/historical engineering
1.3	Mixed (4)	8 to 10	Cartoon: science/comedy
1.4	Mixed (4)	8 to 10	Cartoon: science/drama
1.5	Mixed (4)	8 to 10	News: science/natural history
1.6	Mixed (5)	8 to 10	Game show: mathematics
2.1	4 females	13 to 15	Game show/ reality television: design and engineering
2.2	4 males	13 to 15	Cartoon: science/drama/comedy
2.3	4 females	11 to 15	Game show: Science and history
2.4	3 females	14	Game show: science

3.2.2 The initial questionnaire

The questionnaire was used to elicit participants' pre-existing perceptions of STEM with a view to comparing this data with a larger-scale study of this nature (see Schreiner and Sjøberg, 2004). Furthermore, we aimed to gather background data on participants' television viewing patterns before they began interacting during the group activities.

What follows is overview of the main findings, which also highlights issues that might inform further analysis. For a question-by-question description of results, see Appendix IV.

In total, 45 participants completed the questionnaire. Of these, less than a third (11 in total) stated that they lived with or knew a scientist/engineer; all but one of these was male. Further analysis of the descriptions of the types of scientist or engineer indicates that all of the younger children (KS2) who said they lived with an engineer were describing mechanics or construction workers. For example:

- KS2 male: He fixes and builds washing machines[18]
- KS2 male: (He) fixes bus engines and faulty circuits
- KS2 male: My dad fixes pipes, motors and machines
- KS2 male: Builds doors and stairs
- KS2 female: (He) works with computers and makes parts of cars and racing cars
- KS2 female: Cars he fixes engines

These findings may be partly explained by the location of the school, which was close to a major motor-racing circuit, a source of local employment.

[18] Notwithstanding our additions (in parenthesis) participant descriptions are reproduced verbatim.

In contrast, the descriptions from the older KS3 and 4 children indicate that they knew the difference between types of engineers, also describing medical professionals and teachers. For example:

- KS3 female: She is a scientist in the world of teaching
- KS3 female: (He) makes stuff for diabetics
- KS3 female: He is an engineer. He makes EpiPen[19] for diabetics.
- KS3 female: (He) designs electronic equipment for planes
- KS3 female: (He) designs computer chips for computers

These findings contrast with the greater number of participants (19 in total) who knew a scientist or engineer, of whom 3 were female. Many of the KS2 descriptions of these scientists/engineers also referred to mechanics. For example:

- KS 2 Male: He fixes cars
- KS 2 Male: (He) repairs and fixes cars
- KS 2 Male: (He) fixes machines
- KS 2 Male: My Grampy fixes tractors
- KS2 Female: (Male) fixes cars
- KS2 Female: He works with cars and fixes them
- KS2 Female: (Male) fixes quad bikes
- KS2 Female: (Male) car engines and all sorts

However, there were also examples that suggest that at least some of the KS2 participants were aware of other types of occupation. Again, the emphasis was on repairing, but also including medical professionals. For example:

- KS2 Female: They (male) fix things
- KS 2 Male: (He) fixes our showers
- KS 2 Male: (Male) fixes computers
- KS2 Female: He blows things up
- KS2 Female: He works with people in a factory. There they try to cure illnesses by testing medicines

These findings were also apparent in the KS3 group, which also included examples of medical professionals and an academic.

- KS3 Male: They (male) go around doing jobs and fixing stuff
- KS3 Female: I know two people (male and female). They are doctors
- KS3 Female: My Grandad is a doctor of science. He used to work at a university in Hong Kong.

[19] EpiPen is an auto-injector that can be used for a number of conditions, including the injection of insulin by people suffering from diabetes.

- KS3 Female: (male) not really sure.

Furthermore, we also found evidence of teachers being described as scientists and engineers. For example:

- KS4 Male: More than one (male and female). They are teachers, and therefore have to describe things thoroughly, each teacher has a main point of biology, chemistry or physics.
- KS4 Male: They (male and female) are teachers. They teach.

Overall, these findings suggest that participants had some direct experience of scientists and engineers, at least as they defined them. However, we note that there were some anomalies in the data, e.g. three sisters appeared in the study and only one listed their father as an engineer. Moreover, one female participant did not list her mother as a scientist even though she worked for a pharmaceutical company. It follows that we need to conduct further analyses to address these issues, also to compare our analyses with the findings of larger scale studies of this nature (e.g. see Schreiner, and Sjøberg, 2004) with a view to considering if our results are (a)typical.

Further initial interpretations from the analyses of the questionnaire data indicate that a 'liking' for science seems to decline as the children get older, which is consistent with other research evidence (e.g., see Murphy and Whitelegg, 2006), and also that some children (mostly younger children) want to work in STEM when leave school. Furthermore, very few participants identified STEM as a subject more suitable for boys than girls and similar numbers of girls and boys said science was important for them. These findings indicate that the age of the child may be an important factor in how they perceive STEM. However, we need to conduct further analyses before we draw any firm conclusions.

In terms of viewing patterns, all the children watched television on a regular basis, defined as at least "a few days a week". Nearly half (21 in total) could watch anything they liked, whilst 13 were only allowed to watch certain programmes. Furthermore, 31 of the participants regularly watched television via the internet, 3 of whom stated that they only did this "to watch clips".

Participants were asked to list their favourite three television programmes. 66 were recorded in total, of which 25 were listed by more than one participant. The five most popular programmes are listed below with embedded hyperlinks to programme websites:

Channel	**Name of programme**	**No. of participants**
Channel 4	*The Simpsons*	19
CBBC	*Tracey Beaker*	8
BBC 1	*Dr Who*	7
Channel 4	*Hollyoaks*	7
BBC 1	*Eastenders*	6

By far the most popular programme was the long-running US-produced animated cartoon *The Simpsons*, a programme that regularly features STEM-related storylines and characters (see Jean, 2007 for discussion).

Of the five most popular programmes listed by participants, none were factual and all are broadcast via analogue (and digital) channels. Two were soap operas and one was a children's drama (also the only one to only be specifically broadcast in schedules for children and young people[20]). Four of these programmes are regularly broadcast in early evening and/or primetime slots.

Participants were asked to list programmes that they remembered as including some STEM content, also to note what they remembered about the programme.

Of the 45 who completed the questionnaire, 26 listed such a programme. Of these, the two most popular were:

Brainiac: Science Abuse
Currently in its fifth series, this show is initially first broadcast through the subscription channel Sky One; subsequently it is freely available as a repeat through freeview channels, such as Sky Three.

This programme was listed by seven participants, of whom one was from the KS2 group. These participants remembered the following things about this programme:

- 15 year-old male - They blew things up. They were dressed in yellow overalls wearing safety goggles.
- 15 year-old male - Fun and exciting experiments, fun science facts. Scientist looked like the guy off of Top Gear.
- 13 year-old male - Mainly blowing things up (e.g. caravans) and finding out what should be better in different situations fat or thin. Scientists were in white coats, most of them like normal people in white coats.
- 14 year-old female - The scientists just looked like normal people.
- 14 year-old female - The scientists wore white coats.
- 14 year-old female - He does different tests e.g. explosions, technology.

CBBC Whizz, Whizz, Bang, Bang

This programme was listed by five participants, all of whom one were from the KS2 group. These participants remembered the following things about this programme:

- 8 year-old male - Making crazy inventions.
- 10 year-old female - Camera helicopter.
- 10 year-old female - Making a robotic horse.
- 9 year-old male - A child tells a scientist what to build and they build it.

Neither *Brainiac: Science Abuse* or *Whizz Whizz Bang Bang* featured during the sample periods.

Overall, these findings suggest that extending our sample of programmes to include those broadcast in primetime slots and on digital-only channels would more authentically reflect the range of programmes consumed by children and young people.

[20] We note that *The Simpsons* is broadcast in a number of slots in television schedules, some of which are specifically for children and young people.

3.2.3 The 'draw-a-scientist' (DAS) activity

All the participants (*n*=45) in the study were able to produce a drawing of what they perceived to be a scientist. The adoption of the Chambers' (1983) protocol, alongside the introduction of the project team's additional codes (see Section 2.2) showed some interesting differences between drawings produced by girls and boys, also between the two different age groups.

Most (*n*=33, 73%) of the scientists drawn by both girls and boys were coded as male.[21] Only six drawings (13%) were drawings of female scientists, all drawn by girls. It follows that no boys drew pictures of female scientists, also that several drawings could not be definitely coded as either female or male.

The images of female scientists were all drawn by the younger (KS2) girls apart from one that was drawn by a year 8 girl. (The image drawn by the older girl who drew a female scientist was of a young, slim, attractive bespectacled woman who might have been a successful executive, secretary, librarian, or beauty therapist but for the lab coat and pens in her pocket—see Figure 2a).

One KS3/4 girl deliberately drew an image of a scientist as a "boy or girl", noting in another caption that their scientist "looks like an ordinary person but probably clever/intellectual" (see Figure 2b). This participant went on to list some of the jobs that the scientist might have been doing, illustrating a sophisticated understanding of the nature and purpose of the draw-a-scientist activity, as well as implicitly noting some of the limitations thereof, a finding that is also noted by Mead and Métraux (1957).

Figure 2a: Female scientist drawn by KS3/4 girl

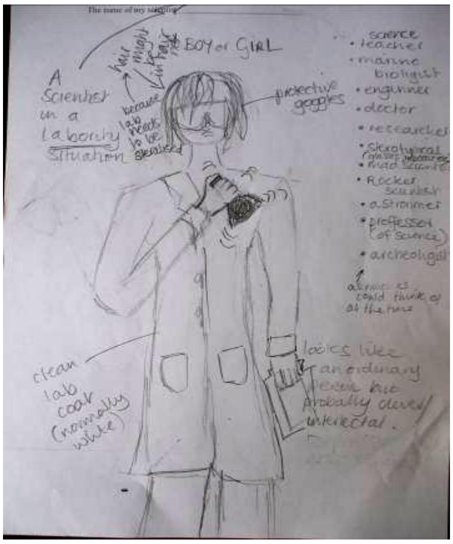

Figure 2b: Gender neutral scientist drawn by KS3/4 girl

The images with the lowest scores on the Chambers scale (0 and 1) were all drawn by girls of female scientists so included fewer indicators of science than the boys' images (see Figure 3a

[21] Wherever possible, the gender of the scientist was coded. For example, we used the name of the scientist, what they were wearing (principally evidence of skirts for females), facial hair and/or baldness (to determine males). In some cases it was not possible to determine the gender of the drawn scientist, e.g. see Figure 2b.

for an example). It follows that none of images of female scientists could be viewed as the stereotypical scientist, at least as defined by Chambers' protocol.

This is in contrast to drawings produced by both girls and boys of male scientists that scored much higher (Figure 3b/c). However, we note that at least one of the codes—bearded—was in itself gendered, so drawings of female scientists were effectively scored out of six, while male scientists could, at least in principle be scored out of seven. This suggests that the protocol itself may need to be revised in the light of the emergence of consistent numbers of female scientists being drawn.

Figure 3a: Female scientist drawn by KS2 girl

Figure 3b: Male scientist [22] drawn by KS3/4 girl

Figure 3ac: Male scientist drawn by KS3/4 boy

The lower scores for scientists drawn by females of female scientists may also be partly explained because two KS2 girls drew faces only and gave them names of girls they might know, i.e. Chloe and Molly.

In contrast, one KS2 girl drew a female astronomer and called her by her own family name (Dr (child's name) see Figure 4a), effectively imagining her future self in this role. However, we also note that this image had few of the symbolic codes for a scientist as defined by Chambers (1983).

We categorised this image as a scientist because of the salutation “Dr (child’s name)” and the telescope aimed at the stars and the moon, and as a female because of the hair, lipstick and earrings.

[22] The name given to the scientist (Prof. Ronald McDougle) indicates the gender.

Figure 4a: Female astronomer drawn by KS2 girl.

Overall, the KS2 group scored lower on Chambers' protocol than KS3/4, suggesting that the older participants had a greater number of symbolic codes to draw on when producing their pictures. This is consistent with earlier findings from draw-a-scientist activities, indicating that, in this respect, these participants behaved similarly to subjects in other DAS studies so were not an unusual population.

Further work with larger numbers of children is needed before any firm conclusions can be drawn from these findings. However, these findings suggest that some girls do now appear to perceive the possibility of scientists being female and some girls in our sample may even be projecting themselves into this role, findings that are consistent with recent DAS activities (Steinke et al, 2007; Rodari, 2007). We attempted to uncover whether this was indeed the case by asking the participants to undertake a reflective writing activity where they imagine themselves as scientists or engineers in the future.

3.2.4 Overview of the carousel activity

All of the programmes, episodes and characters featured in these activities were drawn from our samples of STEM programmes collected during Phase 1 of the study. Details of the programmes, episodes and characters that we used can be found in Appendices II and V.

In Section 3.1.3, we discussed how participants made the distinction between 'doing science' and 'talking about science'. This point is further illustrated in the responses from participants when discussing Michaela Strachan (Strachan has (co)presented various natural history programmes on television for a number of years). Although the participants generally recorded positive comments about her personality, they also made the distinction that she talked 'about science' rather than being a scientist herself.

Participants viewing the extracts of the programme *Primary Geography: the science of wind* also appeared to distinguish between presenters and experts. Two children who carry out experiments present this extract. Furthermore, this extract contained clips of a female television weather presenter, who relates the majority of the information about 'the science of wind', and a male character, who is described as a meteorologist and who explains the purpose of the equipment used at the weather station to the children. In response to the question of which of the characters are scientists Group 1.3 identified 'weather lady, scientist, a boy and a girl'. In conversation with a member of the research team, who has noticed the contradiction in the written response, this distinction is maintained:

Researcher: "So who were the scientists?"

Female participant: "The weather lady, the scientist and the boy and girl."

Researcher: "So the scientist was the man talking about the weather was he?"

Female participant: "Yes"

Group 1.1 identified only 'a meteoreorol' and Group 1.6 wrote that there was '1 scientist'. The audio recordings of this activity show that there was some debate between the members of Group 1.6 concerning which characters were scientists. Watching the extracts for a second time, one male participant responded to the meteorologist being described as a 'professional' by saying "It's the man. He's the professional. He's the scientist" and this was then recorded on the worksheet.

The KS 3/4 group viewed extracts from two programmes about engineering. The first extract related to the design of the Millennium Bridge and the initial problems encountered when people began to use the bridge. The engineer who provided the solution to these problems was a female structural engineer called Sophie Le Bouvre. Le Bouvre is shown talking about her work and is identified by name and job title in captions on the screen. Three of the four groups who viewed these extracts recalled both her name and role. In contrast to this example, the second extracts were taken from a programme that compared 'hard' and 'soft' approaches to designing flood defences. The extracts featured a female engineer who talked about 'soft engineering' and working with the environment to prevent flooding. Her name was given and the caption read that she was from Cambridge University. None of the four groups who viewed these extracts recalled that she was an engineer. Two of the four groups did, however, record that a male contributor to the programme was an engineer, although no indication was given within the programme that this was the case. The captions stated only the name of the male contributor and that he was representing the Wessex Flood Defence Committee.

The only specific references made by the participants to engineering outside of the extracts shown, related to machines which appeared in the programmes. For example, in relation to the programme *Alpha Teens on Machines,* Group 1.6 discussed the machines that the characters used, identified that this must mean that the programme included engineering and wrote 'they have changing veicals for mishons.' Other machines linked to engineering were a space shuttle, a time machine and robots. An illustration of this link between engineering and machinery is provided by the comments of Group 2.2 in relation to the programme *Sonic X* who, in response to the question 'does this programme include any science, engineering or mathematics, wrote **'**It's about a doctor, therefore must be about science. The doctor builds machinery, therefore it is about engineering.'

There were very few instances where the participants identified a programme as containing mathematics, and all but two of these references were related to the US-produced educational animated cartoon *Arthur*. Many episodes of this animated cartoon contain stories of the anthropomorphised aardvark Arthur's experiences at school. Seven of the groups of participants made the link between mathematics and schoolwork. For example:

- ‘Arthur has to do a lot of maths because of his teacher’ (Group 1.6)
- ‘It includes very mild stuff like 1+1 and class work’ (Group 2.2)

The two other references to mathematics were made by the same group and the audio recordings of the group’s discussions reveal that these references were made by one member of the group (KS4 female) who identified mathematics as being related to science and engineering.

Mr Ratburn, an anthropomorphised rat, was one of the characters that the participants were asked to create dialogue for. Mr Ratburn is Arthur’s teacher. He has a particular interest in mathematics. Once again the link between the school environment and mathematics featured heavily in these worksheets with five (3 KS2 and 2 KS3/4) of the groups writing dialogue that referred specifically to mathematics.

As already discussed, news and current affairs programmes were identified as containing science and engineering when they contained reports of inventions or interviews with inventors. This link to invention was also made to the US-produced animated cartoon *Spongebob Squarepants*, which arguably might be seen as a less obvious example of a programme with STEM content.

- ‘Spongebob invents flying pants. The phone rang so he put the hairdryer in his pants and they expended and he hit is head on the celling.’ (Group 1.6)
- ‘Sandy the squid is an inventor.’ (Group 1.2)

The character Spongebob Squarepants is an anthropomorphised (male) sea sponge. Sandy Cheeks is an anthropomorphised (female) squirrel who is often depicted doing science or mathematics.

A further Illustration of the participants’ ability to identify STEM content across different types of programmes is demonstrated by responses to the long-running animated cartoon *Scooby Doo.* This worksheet was only used with KS3/4 participants, but all the groups identified this programme as containing STEM content, linking this to a 'detective' metaphor of scientific investigation, also to forensic science (see also the discussion in the introduction relating to the BBC drama *Silent Witness*):

- ‘To do with all of the above because needs them as a way to solve mysteries’. (Group 2.1)
- ‘Some ways of decoding stuff. Scientific ways to solve a crime.’ (Group 2.2)
- ‘Yes, quite often, they use it to solve mysteries’. (Group 2.3)
- ‘Velma is always explaining how things work when the crime has been solved’. (Group 2.4)

Likewise, two of the groups who wrote dialogue for the US-produced animated cartoon about the superheroes the *Fantastic Four* appeared to draw on their knowledge of science in their responses.

The *Fantastic Four* are: Mr Fantastic (aka Reed Richards or ‘stretch’); The Invisible Woman (aka Susan Richards); The Human Torch (aka Johnny Storm); and The Thing (aka Ben Grimm). All of the characters gained their super-human powers as a result of being exposed to ‘cosmic rays’ during a space mission. Ben (The Thing) has been turned into a 'rock-clad monster' as a result of this exposure. Johnny (the Human Torch) enjoys his super-human powers, but is mainly concerned with the benefits that his celebrity status brings. Reed (Mr Fantastic) is a scientist and Susan (The Invisible Woman), is usually shown assisting Reed in his experiments.

Group 2.1 wrote the following dialogue, correctly linking this to the characters special powers:

> ‘Ben: I could be a metamorphic, igreousor sedimentary rock! Johnny: Turn on the heat. Reed: what happens when my metal cools. Susan: invisibility defys all laws of science.’

And Group 2.2 wrote:

> ‘Ben: I’m made of rock go me! If you leave me by the sea I will shrink dramatically. Johnny: my fire is 400ºC which is hot. Reed: My elasto-compound fused into my genetic make up mean I can stretch to incredible lengths. Susan: I’m wearing a super-hyper-chromatic nylon jumpsuit with inter woven fire resistant bio-plastic undercoat.’

One group responded to the task of writing dialogue for the Fantastic Four by appearing to distinguish between the characters that are scientists (Reed and Susan) and those that are not (Ben and Johnny). Those characters who were deemed to be scientists characterised science as 'interesting' when compared to the non-scientists, one of whom defined science as a 'problem creator' (Ben).

Group 2.4 wrote the following dialogue for these characters:

> ‘Ben: science has turned me into a monster. Johnny: I don’t like it. It’s boring. Reed: it’s amazing. Susan: I like science.’

The way in which characters within animated cartoons can represent either positive or negative images of science and scientists is also demonstrated in the responses to the worksheets where the participants were asked to describe the personalities of the characters.

In the US-produced animated cartoon *Futurama,* Amy is an engineering student who is working as an intern for the male, bald, bespectacled, elderly Professor Farnsworth, who sometimes lectures at the Mars University. Although this connection with engineering is recognised by three of the four groups, descriptions of her personality are correctly identified as not always being positive:

- ‘Bubbly, airhead, rich, happy, sense of humour.’ (Group 2.1)
- ‘[participant’s name] says she’s a half-whit.’ (Group 2.2)
- ‘Snotty, rich, dim, whitty, romantic, friendly.’ (Group 2.3)
- ‘Lovable, shallow, brave, adventurous, clever.’ (Group 2.4)

In contrast, Lisa Simpson (see Jean, 2007 for discussion), one of the key characters in the US-produced animated cartoon *The Simpsons*, and who excels at science and mathematics in school, appears to represent a much more positive image, especially to the older participants:

- ‘Sweet and nice natured, smart, helpful, sence of humour. Science and maths. School and school projects.’ (Group 2.1)
- Shes a smart girl and is interested in science.’ (Group 2.2)
- ‘Smart. Ega to please. Evermentally friendly. Creative. Loves jazz and blues (plays sax) musical. Lisa does – eco friendly – science, engineering. Good grades – maths and science projects.’ (Group 2.3)
- Loves school, clever, caring, musical. Yes – loves maths, does science experiments/projects. Wins prizes. (Group 2.4.)

The comments on the worksheets that asked participants if they remembered particular episodes of programmes suggest that certain episodes have considerable longevity in the minds of children and so may have a powerful effect on creating images in these children's minds.

- Five of the groups (1 KS2 and 4 KS3/4) recognised the episode of the US-produced animated cartoon *Futurama,* and three of the KS3/4 groups made the connection with *Charlie and the Chocolate Factory*. They described the episode as 'mocking' the film and being a 'spoof' of the film.
- Nine of the groups (5 KS2 and 4KS3/4) recognised the episode of *The Simpsons,* shown on the worksheet, and five of the groups mention the 'geeks' or 'nerds' that help Homer with his studies.
- Five of the groups (2 KS2 and 3 KS3/4) recognised the episode of the US-produced animated cartoon *Spiderman.* Three of the groups highlighted the conflict between the scientists Peter Parker (aka Spiderman) and Michael Morbius, with two groups describing Morbius as 'mad' or 'evil'.

Such evidence suggests that (US-produced) animated cartoons represent a range of images of STEM. Children and young people generally interpret these images 'correctly'. These programmes, particularly those that are aimed at a range of age groups and that are repeated regularly, may have an ongoing (but developing) influence on children's perceptions of STEM as they grow up.

3.2.5 The storyboard activity

Each of the groups successfully produced a storyboard plan for their chosen television programme, based on the participant sheet (see Appendix IV). These activities are listed in Table 6. Below we provide short narrative summaries of the groups' plans.

The programmes that the older children devised were:

- A mathematics game show drawing on characters from programmes shown on the activity sheets for the carousel activity, with the pupil answering more questions than teacher.
- A history of science game show using the slogan 'the way to get picked is to be gifted'.
- An engineering programme in the form of a reality TV show. The children designed and engineered a 'landmark' and the process is filmed. At the end of each programme one team is sent home. The programme is called 'Children make their mark'.
- The 'Mad Scientist' game. The mad scientist captures members of the audience and locks them in his underground lab. To escape they must answer a series of questions about science and carry out science experiments against the clock.
- A comedy drama set in a science classroom with stereotyped images of the pupils – the one who answers all the questions (the 'boff'/ teacher's pet), the naughty one, the stupid one, plus an ineffectual science teacher.

None of the older children devised factual programmes. The STEM content was placed in a game show or other context.

The younger children devised programmes as follows:

- Two cartoons based on *The Simpsons'* characters. In one, Lisa Simpson is threatened by a 'Mad Scientist' and is rescued by her older brother Bart.

- A cartoon set in Pompeii with Homer (from Ancient Greece) examining heating and drains built by the Romans.
- A space cartoon about an alien space ship ‘drifting in gently through space’ being damaged by crashing to Earth. A scientist effects a repair which enables the alien to return to space.
- A factual news programme, based on CBBC’s *Newsround*, about endangered bears.

It is clear that many of these children were most interested in creating programmes with STEM content in a game show format that emphasised participation and competition. Only two of the storyboards, both created by the younger children, contained outlines for factual programmes about STEM. Notwithstanding the findings about animated cartoons (see Section 3.2.4), this suggests that children may also be engaged by programmes about STEM that are presented in this way (rather than in documentary styles, for example). This is particularly true for the older children.

These results suggest that this activity has a great deal of potential for further exploration in the next phase of our research. The 'Children Make Their Mark' proposal is particularly interesting. As already mentioned in section 3.2.4, the participants had watched extracts from an educational programme, *Engineering at the Cutting Edge,* which featured a competition involving engineers designing a landmark to celebrate the new millennium. The stimulus for the subject of the storyboard, therefore, had been presented to the participants in an earlier context. However, the translation of the subject to another format, especially one that is currently so popular, was quite sophisticated. In responding to the question regarding topics that they would not like to know more about in the initial questionnaire, the majority of participants did not indicate an interest in either ‘famous scientists and their lives’ or ‘important inventions or discoveries’. The history of science quiz, however, was designed to present this kind of information but translated, once again, into a game show format.

The stereotype of the ‘Mad Scientist’ featured twice in this activity—illustrating evidence of intertextuality[23] (see also Section 3.2.4 and the discussion of *Futurama* and *Charlie and the Chocolate Factory)* both in the older group and younger children’s groups. The older children described their Mad Scientist in stereotypical ways and locating him in an underground laboratory where he held members of the audience who he has captured.[24] They say that he has been “Driven mad by his work, (he) captures his victims to make them do his work”. This included his assistant who was female and was held captive but never seen, suggesting that she is forced to engage in STEM against her will! The younger children also characterise the ‘Mad Scientist’ as an evil figure who threatens Lisa Simpson. The only positive image of a scientist devised by the children is of the scientist who repairs the alien’s spaceship.

A more positive interpretation of STEM could be taken from the game show formats where the game shows present science and maths as a challenge so that those who have the answers reap the rewards.

[23] “Best understood as the textual equivalent of cross-referencing, at a semiotic level intertextuality refers to the use of a given sign in other textual contexts” (Hartley, 2002, p. 126).

[24] We have found several instances of underground or secret laboratories in our study of cartoons and animations, e.g. in the pre-school programme *Harry and his bucketful of dinosaurs*—where Harry ‘creates’ a robot and brings it to life—and *Spiderman* (see Section 3.2.4)—where the scientist Michael Morbius conducts secret genetic experiments using stolen scientific equipment.

3.2.6 The reflective writing activity

This activity[25] was completed by all of the Group 2 (KS3/4) participants, but 2 boys were absent from school on the day the activity was completed by Group 1 (KS2).

The participants were asked to imagine themselves as grown-up and working as a scientist, engineer or mathematician.

Table 7: Distribution of scientists, engineers and mathematicians from the reflective writing activity

	KS2 female	KS2 male	KS3/4 female	KS3/4 male	Totals
Mathematician	1	2	0	0	3
Engineer	7	6	4	1	18
Scientist	9	3	7	3	22

<u>*Mathematicians*</u>

The three participants who imagined themselves as mathematicians all interpreted the role as a mathematics teacher in a school:

- KS2 male: ‘I teach maths to little children in year 2’
- KS2 male: ‘I teach maths, English, PSHE and science but I am mainly a maths teacher’.
- KS2 female: I have been working as a mathematician for three years now. The place where I have been working is a school’.

As already noted in Section 3.2.4 the participants most readily identified mathematics content in relation to narratives about experiences at school and the role of teachers. Although one group of children did story-board a mathematics game show, the two of the characters in the programme were Arthur and his teacher, Mr Ratburn. The narrative for the programme focused on contestants answering more questions correctly than the teacher. (See Sections 3.2.4 and 3.2.5 for a fuller description of responses to the carousel and storyboard activities.)

The three participants who imagined themselves as mathematicians included elements in their narratives that may well have drawn on their experiences as pupils:

- KS2 male: ‘I always carry some number cards with numbers on them so they can make sums out of them…. I don’t like it when people squabble about someone stole their pencil or rubber because it gives me a headache and I really think of getting angry and shouting at them or sending them out of class. But it is only a little squabble so I have to ignore them.’
- KS2 male: ‘The topics I need to find out more about is division because not very many people are very good at it.’
- KS2 female: ‘My most fun bit is when I teach my class because they are very quiet.’

This focus on mathematics within the school environment is, perhaps, not surprising. The experts in mathematics, or ‘mathematicians’, that children of this age will have encountered

[25] For further details of this activity, please see Appendix II.

most often are likely to be their teachers. (We also note that, of the 14 programmes included in our two samples of children's television programmes about mathematics, 8 were educational programmes designed to be shown in schools, 2 were comedy dramas that featured children learning mathematics in school, and 4 were pre-school 'educational' programmes in which the 'mathematicians' were anthropomorphised animals, e.g. the US-produced series *Barney*.)

Of the eight educational programmes, two are from the series *Maths Challenge* and six from the series *Maths Mansion*. The series *Maths Challenge* features an animated cartoon character called Matt Matics, who is a secret agent and who has an assistant called Miss Mini-Pinny. Matt Matics' arch-enemy is Dr Strangeglove. Children contribute to the programme as 'special agents' who help Matt Matics foil Dr Strangeglove's attempts at world domination by solving mathematical problems. In *Maths Mansion* children need to solve mathematical problems to escape the gothic mansion in which they have been imprisoned by Bad Man. They are given guidance on how to solve the problems by Sad Man, who appears to be a maths teacher. Although both of these series might be viewed as providing innovative ways of helping children think about mathematics, especially in their use of humour, it could be argued that the contexts in which both series are set give little information of how mathematics might be put to use outside of the school environment.

In contrast, none the participants who imagined themselves as engineers related their narratives to a school environment. Likewise, only four out of twenty two of the participants who imagined themselves as scientists identified themselves as teachers, although one further participant did describe teaching roles as part of their work in laboratories.

<u>Engineers</u>

Of the eighteen children who imagined themselves as engineers, three (one male and two females: all KS3/4) described roles that would not more readily be associated with the role of a mechanic or, more generally, 'fixing' machines. Eight participants described roles as car mechanics (three male and 5five female). Others worked fixing and maintaining trains, computers, security cameras, plumbing and roads. (These findings are consistent with participant responses to the initial questionnaire—see Section 3.2.2.) It is interesting to note, however, that a similar proportion of the girls (39%) as boys (41%) imagined themselves in these roles.

The three examples of participants constructing narratives that suggest a more sophisticated understanding of the role that engineering might play in future careers provided us with useful data in that they might be viewed as 'aspirational narratives'.

- KS3 male: I am Peter Popodopolous and I have 28 years and I am an architect, for houses in France, Spain, Italy, USA, Africa and M.E. I specialise in green solutions because of global warming, but I do like to use historical architecture in my designs. When I work I wear normal clothes and I work in my office. I use mainly the computer, but also sometimes paper and pencil, though I don't like to do this. I design mainly houses. My favourite part of my job is seeing the expensive houses that go up.
- KS3 female: Since I was younger, I have always wanted to be an engineer. I'm 27 and working with some of the most well-off people (like my husband!) When a building looks like it isn't safe enough, I'm one of the people who go and see what is wrong, say what could be done and test it out.

  I can work anywhere, usually in major cities. I just wear a suit usually, as I don't build anything! The most important parts are making sure it is safe and suitable to use and the most interesting part is designing the new, safer building. The best thing about my job is that I can do my own work in my own environment and I can have breaks when I want them. However, the worst part is you have to attend the problem asap and do the new development by the deadline otherwise you're in trouble.

- KS3 female: 30 years old, and I feel like I have the best job in the world. I love, enjoy and look forward every morning for creating all my ideas and being able to test them in a safe environment. I worked hard to get to the stage I am at and am highly regarded in the aircraft industry. I have worked on a number of projects which have been successful and are being used professionally around the globe. I get such a rewarding feeling when my plane is used, creating a greener, safer and easier way for people to travel. The only possible thing that is slightly bad is the paperwork after a project is created, but even then it is quick, easy and only a small part of the job. I look forward to the day when I can create an entirely new way to travel by air and constantly try and think up ideas to see if they work.

The themes that run across these narratives appear to emphasise:

- 'Problem solving' (as opposed to 'problem creating').
- Independence – all three participants appear to envisage working on self-employed or consultancy basis.
- Status and financial reward – all three participants include references to international travel, high earnings or their professional reputation.
- Job satisfaction – job satisfaction is linked, in part, to value statements, for example
  - I specialise in green solutions because of global warming.
  - The most important parts are making sure it is safe and suitable to use and the most interesting part is designing the new, safer building.
  - I get such a rewarding feeling when my plane is used, creating a greener, safer and easier way for people to travel.
- Modern technology – the narratives suggest that the equipment used in their jobs reflects recent technological developments.

This contrasts with the other narratives of working as mechanics and 'fixing machines', the majority of which made reference to:

- Working within specific local companies or as an employee of a particular type of company and based in the local area.
- Use of manual tools, such as spanners, monkey-wrenches, screwdrivers, drills and tool belts. Clothes worn for work tend to be described as being necessary either for health and safety reasons or to protect everyday clothing. There are three mentions of computers being used at work and one mention of software.

There are few mentions of 'status', but three of the participants, all male, also mention financial reward:

- KS2 male: 'It's important to be a plumber because you get paid quite a lot of money.'
- KS2 male: 'I do six hours a day (except weekends) for £5.80 an hour'
- KS2 male: 'I like getting my payment and taking things apart.'

All of the KS 2 participants, however, identified at least one aspect of their job that they consider to be important or interesting.

Scientists

As already mentioned four of the participants described themselves as science teachers, three working in schools and one who appears to be a science specialist who travels to different schools to 'teach them how to blow up things' (KS2 female).

The remaining eighteen participants described their workplaces as:

- Laboratories and research centres (4 KS2 female; 2 KS 3/4 Female; 4 KS2 Male; 2 KS 3/4 male)
- Sewerage treatment plant (1 KS4 male)
- A science museum (1 KS2 male)
- Offices (3 KS2 female)
- A hospital (1 KS3 female)

These eighteen participants described roles for scientists and, with the exception of two male participants (1 KS2 and 1 KS3/4), these roles would appear realistic and 'achievable'. On the whole participants seem to be able to make links between the tasks they perform as part of their jobs and the topics they are trying to find out more about. For example:

- KS2 female: I do lots of things. I invent new things and look at new stuff that is found. I figure out things for important people […] I am trying to find out more about polar bears because the ice is melting. I think this topic is interesting because I want to help the polar bears.
- KS 2 male: I look for aliens and new planets. I need a telescope and a satellite to look closely at planets.
- KS 3/4 female: I have been working in the hospital for a few years now [….]The best part of the job, apart from saving people, is diagnosing them using all the equipment and monitors because it really tests my medical knowledge and it's great when I solve problems.
- KS 3/4 male: I am a nuclear physics scientist who designs nuclear defence systems. [….] I use computers for my work [….] I test rockets as well as design them [….]To get my job I had to have a degree in maths and nuclear physics.

What is less apparent in the narratives constructed by the participants who envisage themselves as scientists are the 'aspirational' themes identified earlier in relation to engineers. The themes that do emerge, however, may be more realistic in terms of working as a scientist, and reflect the diversity of work that scientists might do.

For example, only two of the participants describe working conditions that suggest they are self-employed or acting as consultants, and both of these scenarios would seem unrealistic.

One KS3 female owns her own laboratory, whilst another KS3 female, whose main job is in teaching, states that she is:

- 'having some fun outside of school researching cures. I wish I could be Marie Curie.
  I can't wait I will achieve my dream someday and when I do, I'll be rich!'

Only nine (three males and six females) of the participants refer to the use of modern technology in their work, but many of these references are to the 'generic' use of computers rather than specialist equipment.

Nine of the participants (two males and seven females) also refer to clothing and equipment that suggest that their work is either dangerous or messy, with two of these participants, both girls mentioning the clothes they have to wear as being one of the aspects of their jobs that they don't like.

- KS3 female: 'The white coat that I wear is not very fashionable but all the other female doctors wear them so its okay'.
- KS 2 female: 'The thing I most hate about my job is the scruffy uniform I have to wear everyday that I go to work.'

Only two other participants (1 KS2 male and 1 KS2 female) refer to financial reward for their work, stating 'My job is important because it's good money to help me survive' and 'but I do get paid a lot of money, I get paid £57 a day.'

The theme that emerges from analysis of these narratives, and which is also seen in the 'aspirational narratives' of participants who imagine themselves as engineers, is that of job satisfaction. For example:

- KS4 male: Hi, I'm Doctor Donim and I work at the UK Cancer Research Centre in Britol. I am 25 years old, and have just graduated from Oxford University, where I studied radiology. My job mainly is to research new cures and therapies to help heal people with cancer. I find my job gives me mixed emotions, happiness, for example, when I discovered a form of radiotherapy that destroys throat cancer. And sadness when I simply cannot find a cure. It's a horrible feeling that people can live or die depending on you." I have to wear a full body coat, and a mask, as my work can produce dangerous results! The equipment I use is the latest technology available and mainly computerised, but some of it is hand-on! Researching cancer is VERY important as it can save billions of lives!

(Emphasis in original)

- KS4 female: I think that a fascinating and incredibly important job would be a scientist researching alternative, but efficient energy sources instead of fossil fuels and nuclear.

  I am a woman, in her late twenties, having graduated from university in a course in fuel engineering (or something similar). At the moment my place of work is a high quality research lab near a rocket base (so we can test possibly highly explosive fuels) funded by the government. Our protective clothing therefore, has to be of the highest quality.

  My job is especially fun at times because being that I'm allowed to experiment with energy production, where there is some risk involved! Brilliant! It's also very interesting and motivating work.

  Of course my job is exceptionally vital in the world of science presently: with the horrible truth of global warming – and time running out, worldwide the pressure is building for a need for alternate energy sources to fossil fuels and nuclear. Either which are highly polluting, thus increasing the greenhouse affect or emitting deadly radiation.

  Although there are other sources of energy which are practically <u>harmless</u> to the environment (solar, wind, hydro, etc.) there are not sufficient enough to support today's economy. This is why my job is so important.

  Unfortunately, to my dislike, the pressure of time is very worrying but the problem of the greenhouse effect must be solved soon.

(Emphasis in original)

As with the engineers, this ‘aspirational’ theme links job satisfaction with value statements. These statements could be divided into two broad groups: one group relating to the environment (2 KS2 females and 1KS3 female) and the other to curing disease (2 KS3 females and 1 KS4 male). These themes do highlight how the participants can envisage a particular ‘problem solving’ role for science, and when combined with a relatively sophisticated understanding of other aspects of what ‘being a scientist’ involves, can also produce what could be described as ‘aspirational narratives’.

3.2.7 Evaluation

As their final activity the KS3/4 participants completed an evaluation form. Questions in Section 1 of the evaluation form asked the participants about their expectations of the day, and focused on determining whether the arrangements we had made to secure informed consent had proved effective.

Sections 2 and 3 however, asked the participants to advise us on which activities were most/least enjoyable and why, and make suggestions as to how we might develop activities for use in future studies.

From the comments[26] recorded in the table directly below, we can see that the activities that the participants enjoyed the most all involved them in creating artefacts, and allowed them some degree of freedom in interpreting the task, whether working individually or as a group.

Enjoyed most	**Enjoyed least**
I enjoyed the writing piece about imagining yourself as a scientist/maths/ engineering. It was a good chance to really apply some scientific knowledge I had in an enjoyable way.	The questionnaires. I found that they did become quite boring and repitive.
Making a TV programme and presenting it to everyone else because I got to use my creative skills and work as a team. It was funny and enjoyable.	Questionnaire because it was a bit boring.
I enjoid the news and channel report because we got to let our ???? go, and I always wanted to you a paper bord.	Drawing becaue I can’t draw.
I enjoyed the making a ‘storyboard’ the best as it was interesting, and something you don’t do much. You also got to choose what you did, which was fun.	I didn’t like the ‘identifying the images’ part as they were a bit boring and you couldn’t get involved and create things.
The drawing the scientist	The still pictures, dull
I liked the bit when we presented our TV program	Going around the table and saying what person that it was on the piece of paper does for a living
The finest bit was when we were making TV programs	Going around the tables and saying what this persific character is.
Creating a TV show advert.	Questinairs
Storyboarding because I got to use my creative skills	Questinairre. I found it boring.
Drawing the scientist. I enjoy drawing and it was	Questionnaire because it repeated itself once

[26] The participant’s exact words have been used.

fun to draw a scientist	and it was boring.
Drawing a scientist – it was fun and creative	The questionnaire – It was not very interesting and it did not need much imagination.
I enjoyed making our own TV show because we got to use our imagination, and it was just really fun.	I didn't like having to do all the questions! (The ones all around the rooms!) As it took along time and wasn't that fun.
Designing a TV program. Got to act.	The writing task. Not very fun.
Filling in the captions on the cartoon sheets	This one
Making the TV programme because we had free will	The writing because it was boring.

Twelve of the participants made suggestions for developing activities.

- Possibly a whole group discussion (with the sheets given. shown to the whole class and then discussed) with the 'experts' recording it and making notes. Or watching various clips (of what was on the sheets) and then discussing them.
- Role play with props that could be recorded and something more to do with maths because there wasn't a lot about it, It was all about science and engineering.
- I think you could have included something to do with maths, as everything was either science or engineering, however it was still OK.
- Pictures of scientists on TV: stereotypical/ordinary (spot difference). Reading a description of stereotypical/ordinary scientist say what you would say a real scientist's job is.
- Asking us what we liked and disliked.
- Acting, role play of a play about a scientist, engineer or mathematician with props, and have it filmed.
- Role play of scientist, engineer or mathematician. with props and a lab coat and filmed. All good.
- Shown us clips of TV programmes (such as cartoons) to give a wider view and not just engineering programme.
- Maybe, asked the children before hand what they liked – (TV shows !?!) And then discuss them!
- Film the performances.
- Filming the performances.
- May have filmed the programmes then watched them.

As the comments above illustrate, the single activity that participants would have liked to have developed further was the story-boarding activity. Indications are that this is a very fruitful area for research which we plan to develop further in phase 3 and beyond.

4 Conclusions and recommendations

The combined analysis of samples 1 and 2 shows that there was a substantial amount of STEM on the five terrestrial TV stations in the two sample weeks. However, it is difficult to make any definitive conclusions as to whether the two sample periods were (a)typical of regular distributions of children's STEM programming. As might be expected, National SET week (week 2 in the sample) had a greater proportion (63%) of the STEM content across the two sample weeks, but we have found no evidence that this distribution can be directly attributed to this event.

1. **We recommend that further samples of data from UK children's television are studied based on the same methods for data collection and analysis we have used with a view to investigating what might count as a 'typical' distribution of STEM. Such a study would provide further evidence of how STEM is represented on UK television at a time of rapid changes in the broadcasting industry.**

We note also that the project has employed a broad categorisation of STEM content and we found much STEM in places where we didn't expect to; 'hidden', for example, within fictional programming, and children's (US-produced) animated cartoons in particular. This indicates that STEM is a significant cultural resource that is drawn on by these programme makers. However, we have no data from production analyses to draw further conclusions with any confidence. (We note that Haran, *et al*. (2008) have addressed aspects of production in their study.)

2. **We recommend that a complementary production study is commissioned that investigates these issues in more detail, one that particularly focuses on how fictional representations of STEM in children's television programmes are produced. Such a study might proactively track the production of a fictional STEM children's television programme from its inception to broadcast (including examination of the commissioning process, casting, filming and post-production).**

Science clearly dominates our analysis of the two sample periods when compared to technology, engineering and mathematics.

3. **We recommend that greater emphasis is placed on the representation of technology, engineering and mathematics on children's television with a view to increasing the visibility of these subjects. This emphasis should not be at the expense of programmes featuring science, rather the aim should be to increase the overall representation of STEM on UK children's television.**

4. **We recommend that greater emphasis is placed on the representation of women technologists, engineers and mathematicians on UK children's television. This emphasis should not be at the expense of efforts to represent more women scientists on UK children's television (see also Recommendations 6 and 7).**

We note, however, that the nature of science portrayed in some of the extracts represented science as a 'problem creator' as well as a 'problem solver'. Notably, this is regardless of gender issues. It follows that, whilst gender is a central issue requiring evidence-based interventions, the nature of STEM more generally may also require attention.

5. **We recommend that greater emphasis is placed on *diverse*, *authentic* representations of STEM in fictional children's television programming, particularly within animated cartoons produced for children and young people. Such an approach would promote pluralistic portrayals of STEM as it is currently enacted in a range of 'real-world' settings.**

The overall analysis of the speaking actors in the programmes featuring STEM in our two sample weeks show that males dominate. However, this masks some more nuanced patterns within the types of programmes. For example, this pattern is marginal in news and current affairs, where there is almost an equal ratio with females. In the pre-school programmes, male speakers take slightly more than half of the speaking roles with the remaining half being shared by females, speakers whose gender it was not possible to categorize (e.g. anthropomorphised creatures) and male/female groups. The relatively high number of females speaking in the news and current affairs programmes may be explained by the regular appearance of female presenters on CBBC's *Blue Peter*, and female newsreaders and reporters on CBBC's *Newsround*.

6. **We recommend that representations of STEM experts in UK children's television programmes should also reflect *authentic* and *diverse* portrayals, in terms of gender (also age, ethnicity and not only those who conform to the slim, attractive, bespectacled emerging image described in the introduction). Such an approach should promote pluralistic portrayals of actual STEM professionals, working within their specialist fields.**
7. **When women are used in this way, the programme makers should make it very clear that the woman is the expert, e.g. by displaying her as an authority figure, using her title and profession on screen.**
8. **We recommend that targets are introduced for the number of female and male STEM professionals that are represented in a wider range of children's television programmes. Achievement of these targets should be published regularly by broadcasters, alongside short—medium—long-term plans for how they are being improved.**

Whilst female *presenters* talking about STEM on TV is an improvement on women being invisible from STEM-related contexts on children's TV, these are not authentic portrayals of those women actually working as STEM professionals. Whether this has any affect on girls' (and boys) perceptions of STEM as something appropriate for them requires further analysis. However, our reception study showed that the children in this study were quick to recognize presenters and to distinguish them from the authentic 'experts' (scientists/engineers) in the programmes.

The type of programme that shows the greatest proportion of male speakers is cartoons and animations. This may be because, when basing stories around STEM content, animated cartoons rely more heavily on the use of stereotypes and intertextuality to rapidly communicate messages to their audience. Given that the stereotype of STEM referred to by many of the children in this study, e.g. see the Draw-a-scientist activity, is that of the male, lab coat-wearing, bespectacled chemist, and that the evidence from the carousel activity suggests that participants in this study had a sophisticated working knowledge of oft-repeated episodes from these (mainly US-produced) series, our initial conclusions of this data suggest that animated cartoons may play an important role of the (re)construction of stereotypical images of STEM as children grow up.

Cartoons and animations are not restricted to representing 'reality' *per se*, indeed, they have the obvious potential to imagine human relations in many diverse and idealized forms, as does drama and science fiction, the finding that cartoons and animations (re)construct gendered images of STEM is of obvious concern. As other fictional television programmes, such as the BBC drama *Silent Witness* (featuring the female forensic pathologist Professor Sam Ryan), *Star Trek Voyager* (featuring the starship Captain Kathryn Janeway, *The Simpsons* (featuring the child character Lisa Simpson [see for Jean, 2007 discussion]) have shown, it is possible to cast female STEM characters in important roles and produce a successful television series.

9. **There is scope to present imagined, idealized images of STEM in animated cartoons, including ones that feature female scientists and engineers in central roles. Given the global media marketplace that now exists we note that many of these programmes are bought in from other countries, typically North America. As fewer original children's television programmes are being made in the UK (see Ofcom, 2007 for discussion) it may therefore be difficult to effect change. Cooperation and coordination with international organizations and institutions that have a role to address issues of gender in STEM media portrayals may provide a possible solution.**

Educational programmes featuring STEM show a similar ratio of male to female speakers as cartoons and animations. This is more surprising as these are generally made in the UK and have been associated with the requirements of STEM curricula across the UK. It might have been expected therefore that some degree of gender balance would by now have been achieved with these programmes, particularly as the low participation of girls in STEM has been an issue for decades.

10. **We recommend that STEM educational programmes are made with reference to the needs for *diverse*, *authentic* images of female (and male) experts. This issue should be considered when purchasing STEM educational programmes made in different countries (see also recommendations 3, 4, 5, 6, 7, 8 and 9).**

The numbers of male speakers in pre-school programming is also surprising, however this type of programme is more difficult to analyze as the use of anthropomorphized creatures and groups of children singing for example make categorization by gender more difficult. There could therefore be more 'female' speakers than it was possible to count.

11. **We recommend that further work is commissioned to investigate how pre-school children make sense of STEM programmes and the representations of gender (neutrality) therein.**

The results of the initial questionnaire suggest that the KS2 participants have different images relating to scientists or engineers, in particular the younger children who appear to categorize engineers as people who "fix things". Further analysis suggests that they were referring to mechanics as engineers, in part, because of their direct knowledge and real-world experience of people they know working in the local motor racing industry. These findings complement those from Kitzinger *et al*. (2008) who note that adult female interviewees argued for a greater range of media portrayals of women engineers working in real-world situations, with the very real possibility that such images may appeal to (at least some) audience members. Taken together these findings are indicative of the complex processes of reception (see Kitzinger, 1999 for discussion): no one portrayal of STEM will be attractive to all viewers. Rather, if diverse portrayals of STEM are shown, one (possibly several) may be attractive to a given audience member, others (even all of them) could be rejected out of hand. And audience member's attitudes to such portrayals are likely to change throughout the course of their lives, as they gain knowledge and experience and develop their attitudes and beliefs.

The results of the Draw-a-scientist activity were consistent with previous research using this instrument showing a small increase in the numbers of female scientists being drawn, all drawn by girls. It is also interesting that these images of female scientists did not conform to stereotypical imagery, at least as defined by Chalmers (1983); several were images of the children themselves or people they knew. This suggests that some girls are willing to project themselves into this role in the future.

Findings from the carousel activities suggest that particular (regularly repeated) episodes of (US-produced) animated cartoons featuring STEM can have considerable longevity in the minds of children and so may have an ongoing influence in (re)constructing images of STEM.

The children generally recognized who were the scientists in other types of programmes (e.g. educational), but typically missed acknowledging some of the females as the expert scientists or engineers even when it was highlighted in the programme. Some participants in the carousel activities were able to distinguish between presenters and experts in the extracts they were shown. This raises the issue of the lack of clarity in the programmes between presenters who talk about STEM but who are not STEM professionals, or not practicing STEM on-screen and authentic experts who are.

See recommendations 6, 7 and 8.

The storyboarding activity produced some very interesting outcomes and proved a rich area of the research which we will be developing further in the next phase of our research. The children and young people engaged with this activity with considerable enthusiasm and the evaluation showed that they would have liked to do more of this. They produced some potentially fruitful ideas for programmes that combined popular types of programmes such as game shows and reality TV in a STEM context. The reflective writing activity added further evidence of children and young people's aspirational images of scientists and engineers in particular. Their self concept of these subjects was focused on professional lives that involved helping people and animals, and environmental concerns.

12. **Programme makers should engage with children and young people to find out what sort of programmes about STEM they would like to watch. Inviting children and young people to produce, discuss and then pitch their ideas for programmes may be a fruitful avenue for this type of activity.**

Given further research and development, and sufficient resources, it should be possible to develop a pack of teaching and learning resources that encourages children and young people's creativity in developing ideas for future STEM programmes. With the progress of technological developments, these programmes could be (at least partly) produced by children and young people, adding to the teaching and learning resource. Such a pack could be used by teachers to facilitate reflection by children and young people on the portrayals of STEM that they witness on television.

13. **We recommend funding is made available for the research, development and authentic trialing of these resources.**

The results so far suggest that TV programmes do have some influence on children and young people's images of STEM. Women are not invisible in these types of programmes, but the issue remains as to whether they are visible enough, particularly in terms of the diverse, authentic representations that could make a real difference. This research has suggested some avenues for further exploration which we aim to pursue in the next phase with a view to informing ongoing debates about the influence of popular culture on girls' identities and subsequently on further and higher education choices and uptake of careers in STEM by girls (and boys) and women (and men).

14. **We recommend that the conclusions and recommendations from the (In)visible Witnesses project are submitted to the current Ofcom (2007) consultation on the future of children's programming in the UK by 20th December 2007, the deadline for responses to the consultation**.

5 Future work

Over the period from December 2007 to the end of March 2008, we propose to extend our study to include detailed analysis of a small number of STEM-related examples from selected digital broadcasts. These programmes have been identified as favoured viewing by the children and young people involved in the current study and some are transmitted during primetime slots, i.e., outside scheduled children's programming hours (the focus of the study to date). This extension to the current study also aims to include associated branded media, such as programme websites.

Extending the study to March 2008 will also enable some additional in-depth work on our existing sample to include, for example, a gender analysis of the narrative structures in the STEM-related extracts for children and young people.

We also aim to do further work with children and young people building on the methods we have developed in the current phase of the project, specifically with the 'storyboard' activity where children and young people design their own TV programmes. Indications are that this may be a very fruitful area of the research that deserves further investigation and holds promise for the delivery of key recommendations on the writing and production of programmes featuring STEM for children and young people.

This additional work will specifically address issues of media literacy (see Livingstone, 2003 for discussion), as discussed recently by Ofcom as a priority area for development.

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Appendix I
Project dissemination

Members of the project team will be presenting work related to this project at a number of events listed below.

Poster presentation planned for the 'Moving gender and SET Research Forward: New approaches and practices', Open University and UKRC for Women in SET Research dissemination Conference, 29 November, 2007, Horwood House, Milton Keynes.

Symposium at the 2008 International Public Communication of Science and Technology (PCST) Conference (see http://www.vr.se/pcst) on the findings of the (In)visible Witnesses Project and the complementary Cardiff University-based project (proposal submitted, awaiting review).

BERA SIG Research Conference at the Annual Association for Science Education meeting at Liverpool University on 5 January 2008 (paper accepted).

Discourse, Power, Resistance Conference , DPR7: Cultures in Resistance, to be held in March 2008 at Manchester Metropolitan University. http://www.esri.mmu.ac.uk/dpr/ (proposal in preparation).

Papers on this work have been presented at the following:

Carr, J. 'The Media and the Politicisation of Education' seminar organised by the Pedagogy, Learning and the Curriculum (PLAC) research group at the Open University, 10 October 2007.

Whitelegg, L. and Holliman, R. (2007). The '(In)visible Witnesses Draft Report: findings and recommendations', presented to the UKRC Steering Group, held at Engineering Training Board, London, 10 October.

Holliman, R. (2007). 'Invisible Witnesses? Investigating gendered representations of scientists, technologists, engineers and mathematicians on UK television – an update on progress', presented at the UKRC-funded National Steering Group, held at the Engineering Technology Board, London, 20 March.

Whitelegg, L. and Holliman, R. (2007). 'Invisible Witnesses? Investigating gendered representations of scientists, technologists, engineers and mathematicians on UK television', presented at the UKRC/JIVE Research Seminar, held at the Open University, 1 February.

Holliman, R. and Whitelegg, L. (2006) 'Invisible Witnesses? Representations of gendered science on UK television', presented at the Public Awareness of Science (PAWS) Seminar "Science outside the box", held at the Institute of Engineering and Technology, 4 December.

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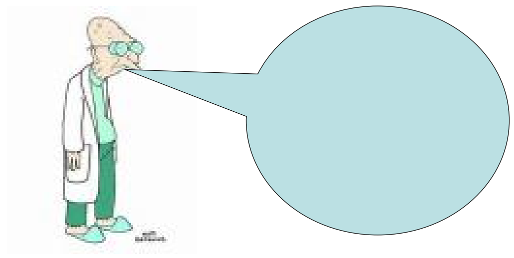
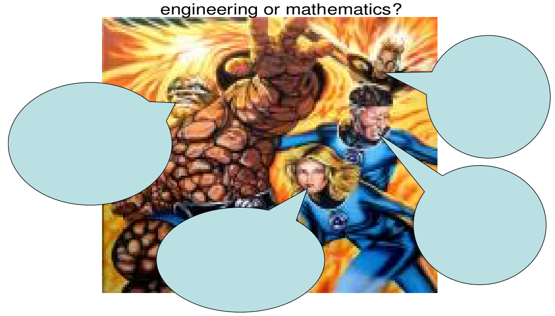
Appendix II
Illustrating the detailed procedure for Phase 2 for the two class-sized groups

Stage	Activity	Group 1: Key Stage 2[28]	Group 2: Key Stage 3 & 4
1	Initial questionnaire - see Appendix III.	Completed in advance under supervision of class teacher.	Completed as first activity of the day-long session.
2	Draw-a-scientist activity.	Instructions: “Draw a scientist”. Towards completion of activity, “please give your scientist a name and put your first name on your sheet”.	Instructions: “Draw a scientist”. Worksheet was headed ‘My name/pseudonym’ and ‘The name of my scientist’.
3	Carousel. Table 1 – identifying programmes. Ten pictures per table – e.g. see right. Format of worksheets as shown.	Do you recognise the programme? Does the programme include science, engineering or mathematics? How?  1. ______  2. ______	 Do you recognise the programme? YES NO In your group, discuss whether this programme includes science, engineering or mathematics in any way. Make some notes on your discussion in the box below.

Stage	Activity	Group 1: Key Stage 2	Group 2: Key Stage 3 & 4

[28] At the KS2 school 30 children completed the questionnaire. Of these 30 children, 28 children completed the reflective writing activity and 25 took part in the remaining activities.

3 continued	Carousel. Table 2 – identifying actors. 26 characters for Group 1, 14 for Group 2 – e.g. see right. Format of worksheets as shown.	Who are the characters? Are they male or female? How old are they? Do they talk about science, engineering or mathematics? If you think they do, what sort of things do they talk about?  1. ____________ ____________ ____________ ____________  2. ____________ ____________ ____________ ____________	Who is this character? ________ Are they male or female? ________ How old are they? ______ What sort of personality does this character have?  Do they talk about science, engineering or mathematics? If you think they do, what sort of things do they talk about?
3 continued	Carousel. Table 3 – identifying episodes. Four per group – e.g. see right and Appendix V. Format of worksheets as shown.	Have you seen any programmes from this show? Have you seen this episode? If you remember this episode, what was it about?   ____________ ____________ ____________ ____________ ____________ ____________ ____________ ____________ ____________	Have you seen any programmes from this show? Have you seen this episode? If you remember this episode, what was it about?   ____________ ____________ ____________ ____________ ____________ ____________ ____________ ____________ ____________
Stage	**Activity**	**Group 1: Key Stage 2**	**Group 2: Key Stage 3 & 4**

3 continued	Carousel. Table 4 What might the characters be saying. 7 characters for Group 1, 8 for Group 2 – e.g. see right. Format of worksheets as shown.	What might this character be saying about science, engineering or mathematics? 	What might these characters be saying about science, engineering or mathematics? 
4	Viewing extracts.	Participants viewed two clips, completing the same worksheet after each clip. The clips were from *Newsround* and *Primary Geography: The science of wind*. Worksheet with the following questions: • Is this a programme you regularly watch? • Are there any scientists, engineers or mathematicians in these extracts? • If so, which characters are they? • Describe them. • What do they talk about? • What are they doing? • Do you like them?	Participants viewed the same two clips as a single group, one immediately after the other, taking notes as they went based on the following questions: • Were there any scientists, engineers or mathematicians in the extracts? If so, could you give their names and/or describe them? • What were they talking about and/or doing? • Did you think that the work they were doing was important? If so, could you give your reasons why you think their work is important? The extracts were: *Engineering at the Cutting Edge* and *GCSE Bitesize Geography*.

<table>
<tr><th>Stage</th><th>Activity</th><th>Group 1: Key Stage 2</th><th>Group 2: Key Stage 3 & 4</th></tr>
<tr><td>5</td><td>Storyboard.

Prepared in small groups and then presented to the whole group.

Both groups followed the same instructions.</td><td colspan="2">Instructions

We would like you to work together in your groups to think about a television programme about science, engineering or mathematics that you would like to produce and present today. This afternoon we would like you to present your ideas to the rest of the class.

Follow the instructions below and tick the activities off as you complete them. Please ask for advice if you are getting stuck.

What type of programme are you producing?
Choose from: cartoon; natural history programme; news and current affairs programme; schools/learning programme; comedy; drama, reality television, game show, soap opera, documentary, film.

What is your television programme about?
Think of a story or issue that involves science, engineering or mathematics to write about. If could be about a programme that you remember watching, or one that you have made up. Once you have agreed on the story, please write this down, or make a comic strip version of the story.

Think about who you want to be a part of your programme?
Do you want to include presenters and other characters? Make a list of the names of any presenters or characters that you would like to include and the roles they are playing in your programme. Are any of your presenters or characters scientists, engineers or mathematicians

Think about the presenters and characters that you have decided to include.
How old are they? Are they are male or female? What they wear? What they do in the story? What do they say? You can either write your answers down, or make drawings of the main characters to add to your comic strip.</td></tr>
</table>

Stage	Activity	Group 1: Key Stage 2	Group 2: Key Stage 3 & 4
6	Reflective writing - Completed individually. Both groups followed the same instructions. Group 1 completed this stage one week after the group activities under supervision of class teacher. Group 2 completed this at the end of the day-long session.	Imagine yourself as a scientist, engineer or mathematician Imagine that you are grown up and work as a scientist, engineer or mathematician. Please put a circle around which job you would like to do. Scientist Engineer Mathematician You are free to work on anything that you think is important and interesting. Please tell us more about the sort of work you think you might like to do. You might like to use the questions below to help you to plan your writing, but you can also tell us about any other aspect of your job that you think is important. • What age are you? • Are you a man or a woman? • Where do you work? • What do you do? • What kind of equipment do you need to do your job? • What do you need to wear when you are working? • What part of doing your job do you think will be the most fun? • What topics are you trying to find out more about? • Why do you think these topics are important or interesting? • What do you like best about your job? • What don't you like about your job?	

Stage	Activity	Group 1: Key Stage 2	Group 2: Key Stage 3 & 4
7	Evaluation	Group 1 did not complete the evaluation.	Participants were first asked questions relating to informed consent, then asked to comment on the days activities: <u>Your experiences</u> Which activity did you enjoy the most? Why? Which activity did you enjoy the least? Why? <u>Your advice</u> You were our 'experts' for the day. Can you think of any other activities that we might have included that would have helped you tell us what you think about images of science, engineering or mathematics on TV? Please use the box below to tell us about anything you feel we might have done differently.

Appendix III
Initial Questionnaire
Page 1

Some questions about you

1. **How old are you?** I am ………………years old.
2. **Are you a boy or a girl ?** I am a …………….
3. **Does anyone you live with work as a scientist or an engineer? Please put a circle around your answer** YES NO

- *If you have put a circle around the answer **NO**, you do not need to answer any more questions on this page. You can turn to Page 2 of the questionnaire and begin answering the next set of questions.*
- *If you have put a circle around the answer **YES**, please try and answer the rest of the questions on this page.*

a. Are they male or female? Please put a circle around your answer.

MALE FEMALE

b. Think about the scientist or engineer that lives with you. Can you tell us something about the kind of work they do? Please write your answer in the space below.

<u>Page 2</u>

4. **Do you know anyone who is a scientist or engineer? Please put a circle around your answer** YES NO

- *If you have put a circle around the answer **NO**, you do not need to answer any more questions on this page. You can turn to Page 3 of the questionnaire and begin answering the next set of questions.*
- *If you have put a circle around the answer **YES**, please try and answer the rest of the questions on this page.*

a. Are they male or female? Please put a circle around your answer.

MALE FEMALE

b. Think about the scientist or engineer that you know. Can you tell us something about the kind of work they do? Please write your answer in the space below.

Page 3

Scientists and engineers as people

5. **What do you think a typical scientist or engineer is like as a person?**

Two words are put opposite each other like this:

Lazy 1 2 3 4 5 Hard working

If you think a scientist or engineer is **very** lazy, then you should put a circle around the number 1.

If you think a scientist or engineer is **very** hard-working, then you should put a circle around the number 5.

If you think the answer is somewhere in between, then you should put a circle around either number 2 or number 3 or number 4.

I think a scientist or engineer is:

Untidy, sloppy	1	2	3	4	5	tidy, neat, orderly
Intelligent, bright, clever	1	2	3	4	5	not intelligent, bright or clever
Lacking ideas & imagination	1	2	3	4	5	imaginative and full of ideas
Caring for others	1	2	3	4	5	selfish
Lazy	1	2	3	4	5	hard-working
Doesn't have many friends	1	2	3	4	5	has lots of friends
Boring	1	2	3	4	5	interesting & exciting
Kind	1	2	3	4	5	unkind

<u>Page 4</u>

<u>Science in action</u>

6. **When you think of 'science', what comes to your mind? Place a tick at the words that you connect with science, leave the others blank. You may tick as many places as you like.**

Science is…….	**Yes! ✓**
Interesting and exciting	
Boring	
Creates problems for society	
Creates pollution	
Useful for everyday life	
Doing experiments	
Most suitable for boys	
Most suitable for girls	
Powerful	
Important for everyday life	
Important for me	
Destructive and dangerous	
Difficult to understand	
Easy to understand	
Something I would like to do when I have left school	

Page 5

Things I like to learn about

7. **Imagine that you could decide what to learn more about. Look at the topics in the table below:**
   - If you would like to learn more about the topic, tick the 'Yes' box[29]
   - If you aren't really sure, tick the 'Don't know' box.
   - If you wouldn't like to learn more about the topic, tick the 'No' box

Things I like to learn about	Yes	Not sure	No
The car and how it works			
Why birds and planes can fly			
How animals like birds or fish navigate			
Plants and animals			
How the body works			
Bacteria, virus and how they cause diseases			
Vaccination and prevention of diseases			
What we should eat to be healthy			
Detergents, soaps and how they work			
Dinosaurs and why they died out			
How the eye can see			
What are colours and how do we see different colours?			
How the ear can hear			
Sounds and music from birds and other animals			
Earthquakes and volcanoes			
The weather and we can forecast it			

[29] In the version of the questionnaire completed by participants in the study, the categories 'Yes', 'Don't know' and 'No'—see also Question 11—were represented by icons. We have replaced these icons with the equivalent words as the former were incompatible with the production of a .pdf version of this report.

Page 6

Things I like to learn about	Yes	Don't know	No
Why the sky is blue			
The greenhouse effect and how it might be affected by humans			
How mountains, rivers and oceans change and develop			
Rockets and space travel			
The moon, the sun and the planets			
Electricity, how it is produced and used in the home			
Alternative sources of energy: from the sun, from wind etc.			
How things like mobile telephones, radios, computers and televisions work			
How science and technology may help us to get a better life			
The possible dangers of science and technology			
Food processing, conservation and storage			
Poisonous plants and mushrooms			
How to improve the harvest in gardens, allotments and farms			
How we can protect air, water, woods and the environment			
X-rays and ultrasound in medicine			
How science and technology may people with disabilities			
How scientists think and work			
Famous scientists and their lives			
Important inventions and discoveries			
How radioactivity affects life and my body			
Chemical elements and their properties			

Page 7

Learning about Science and Scientists

8. **What is the most enjoyable thing you have done in a science lesson?**

Please write you answer in the space below.

9. **Can you think of a famous scientist?** If you can, please write their name in the space below.

10. **Do you know what they are famous for?**

Please write your answer in the space below.

Page 8

Important for your future job

11. If you were free to choose **any job you like**, what do you think is important?

- If you think something is important, tick the 'Yes' box
- If you aren't really sure, tick the 'Don't know' box.
- If you think something is not important, tick the 'No' box

	Yes	Don't know	No
Work with people instead of things			
Have more time for my own friends			
Use my talents or abilities			
Earn lots of money			
Have an exciting job			
Have more time for my family			
Make my own decisions			
Make and invent new things			
Control other people			
Become famous			
Get a secure job			
Have more time for my own interests and hobbies			
Help other people			
Have an easy and simple job			
Developing new knowledge and skills			

Page 9

Some questions about watching television

12 **What are your three favourite television programmes? Write your answers below:**

1. ……………………………………………………………………………………………….
2. ……………………………………………………………………………………………….
3. ……………………………………………………………………………………………….

13. **Can you remember watching a programme that was about science, or that contained a scientist?**

Please put a circle around your answer YES NO

14. **If you answered 'yes' to the previous question, what was the programme called? Do you remember what it was about? What did the scientist look like and what were they doing in the programme?**

Please write your answer in the space below. Please write about more than one programme if you can. Your choice might include a news programme, a cartoon or comedy, even a schools programme.

Page 10

15 **Now we are going to talk about when you watch television. How often do you usually watch TV?**

TICK ONE SQUARE ☑

Everyday ☐

Most days, but not everyday ☐

A few days a week ☐

Only on weekends ☐

A few times a month ☐

Only at other people's houses or at school ☐

I don't watch TV ☐

Page 11

Some questions about watching television

16. **In some families, there may be rules about watching TV. In your home do grown-ups say anything about when or what you can watch on TV?**

TICK AS MANY CIRCLES AS YOU LIKE

I'm only allowed to watch a certain amount of television ○

I'm only allowed to watch certain programmes ○

I can only watch at a certain time ○

I can't watch TV before breakfast ○

When I have finished my homework ○

It has to be turned off at mealtimes ○

When I have finished special jobs or things like music practice ○

I am not allowed to watch TV at other people's homes ○

No, I can watch anything I like ○

No, I don't watch TV at home ○

<u>Page 12</u>

<u>Some questions about watching television</u>

17. **Where do you mostly watch television in your home?**

<u>TICK ONE SQUARE</u>

In the lounge room ☐

In the family room/room for kids ☐

In the kitchen ☐

In my bedroom ☐

In my brother's or sister's bedroom ☐

In my parent's bedroom ☐

In the dining room ☐

I don't watch TV at home ☐

Somewhere else (please write in) …………………………………………..

It is now possible to watch some TV programmes on your computer by connecting to the internet. Please put a tick in the box if you have ever watched TV this way?

☐

END OF QUESTIONNAIRE

THANK-YOU ☺

Appendix IV
Questionnaire data

Question 3

Table IV.1a: Does anyone you live with work as a scientist or an engineer?

	KS2		KS3 and 4		Combined sample	
	Yes	No	Yes	No	Yes	No
Scientist or engineer	6	24	5	10	11	34

Table IV.1b: Are they male or female?

	KS 2		KS3 and 4		Combined sample	
	Female	Male	Female	Male	Female	Male
Scientist or engineer	0	6	1	4	1	10

Question 4

Table IV.2.a: Do you know anyone who is a scientist or an engineer?

	KS2		KS3 and 4		Combined sample	
	Yes	No	Yes	No	Yes	No
Scientist or engineer	13	17	6	9	19	26

Table IV.2.b: Are they male or female?

	KS 2		KS3 and 4		Combined sample	
	Female	Male	Female	Male	Female	Male
Scientist or engineer	0	13	3[30]	6	3	19

[30] In 3 instances the children identified more than one person, and the people identified were male and female.

Question

5: Scientists and engineers as people

	Untidy, sloppy	Tidy, neat and orderly
KS2	**3**	12
Female	3	**3**
Male	0	**9**
KS3/4	**1**	4
Female	0	**3**
Male	1	**1**
Total	4 (8.8%)	16 (35.5%)
Female	**3**	**6**
Male	**1**	**10**

	Intelligent, bright and clever	Not intelligent bright or clever
KS2	**25**	2
Female	16	**1**
Male	9	**1**
KS3/4	**12**	1
Female	8	**1**
Male	4	**0**
Total	37 (82.2%)	3 (6.6%)
Female	**24**	**2**
Male	**13**	**1**

	Lacking ideas and imagination	Imaginative and full of ideas
KS2	**2**	23
Female	1	**14**
Male	1	**9**
KS3/4	**0**	11
Female	0	**8**
Male	0	**3**
Total	2 (4.4%)	34 (75.5%)
Female	**1**	**22**
Male	**1**	**12**

	Lazy	Hardworking
KS2	**1**	22
Female	1	**16**
Male	0	**6**
KS3/4	**0**	10
Female	0	**9**
Male	0	**1**
Total	1 (2.2%)	32 (71.1%)
Female	**1**	**25**
Male	**0**	**7**

	Caring for others	Selfish
KS2	**12**	0
Female	8	**0**
Male	4	**0**
KS3/4	**2**	3
Female	2	**2**
Male	0	**1**
Total	14 (31.1%)	3 (6.6%)
Female	**10**	**2**
Male	**4**	**1**

	Doesn't have many friends	Has lots of friends
KS2	**1**	22
Female	1	**13**
Male	0	**9**
KS3/4	**3**	5
Female	0	**4**
Male	3	**1**
Total	4 (8.8%)	27 (60.0%)
Female	**1**	**17**
Male	**3**	**10**

	Boring	Interesting and exciting
KS2	**1**	25
Female	1	**15**
Male	0	**10**
KS3/4	**2**	9
Female	1	**8**
Male	1	**1**
Total	3 (6.6%)	34 (75.5%)
Female	**2**	**23**
Male	**1**	**11**

	Kind	Unkind
KS2	**25**	2
Female	15	**2**
Male	10	**0**
KS3/4	**5**	2
Female	5	**1**
Male	0	**1**
Total	30 (66.6%)	4 (8.8%)
Female	**20**	**3**
Male	**10**	**1**

Question 6: When you think of science, what comes to your mind?

	KS 2		KS3/4		Total	
	Male	**Female**	**Male**	**Female**	**Male**[31]	**Female**[32]
Interesting and exciting	11	12	4	5	**15** (88.2%)	**17** (60.7%)
Boring	2	5	2	5	**4** (23.5%)	**10** (35.7)
Creates problems for society	5	1	3	2	**8** (47.0%)	**3** (10.7%)
Creates pollution	2	2	2	2	**4** (23.5%)	**4** (14.2%)
Useful for everyday life	8	10	4	9	**4** (23.5%)	**19** (67.3%)
Doing experiments	11	15	3	10	**14** (82.3%)	**25** (89.2)
Most suitable for boys	11[33]	15[34]	0	2	**11** (64.7%)	**17** (60.7%)
Most suitable for girls	10	15	0	1	**10** (58.8%)	**16** (57.1%)
Powerful	6	10	0	4	**6** (35.2%)	**14** (50%)
Important for everyday life	9	8	4	8	**12** (70.5%)	**16** (57.1)
Important for me	3	8	1	6	**4** (23.5%)	**9** (32.1%)
Destructive and dangerous	6	3	3	3	**9** (52.9%)	**6** (21.4%)
Difficult to understand	8	10	1	5	**9** (52.9%)	**15** (53.5%)
Easy to understand	6	7	2	2	**8** (47.0%)	**9** (32.1%)
Something I would like to do when I have left school	4	7	1	2	**5** (29%)	**9** (32.1%)

[31] % of all males in study
[32] % of all females in study
[33] Of these 11, 8 also ticked the 'most suitable for girls' box
[34] Of these 15, 14 also ticked the 'most suitable for girls' box

Question 7: Things I like to learn about

- Topics that 50% or more of female participants indicated that they would like to learn more about

Things I like to learn about	Female	Male
Why dinosaurs died	68%	**53%**
How animals like birds and fish navigate	64%	**23%**
Plants and animals	64%	**29%**
Poisonous plants and mushrooms	64%	**59%**
What are colours and how do we see different colours?	61%	**29%**
How the eye can see	57%	**58%**
Sounds and music from birds and other animals	57%	**35%**
X-rays and ultrasound in medicine	54%	**59%**
The possible dangers of science and technology	54%	**52%**
Earthquakes and volcanoes	53%	**88%**
Why the sky is blue	53%	**23%**
How things like mobile telephones, radios, computers and televisions work	53%	**70%**
The moon, the sun and the planets	50%	**70%**

- Topics that 50% or more of the male participants indicated that they would like to know more about

Things I like to learn about	Male	Female
Earthquakes and volcanoes	88%	**53%**
Rockets and space travel	70%	**46%**
The moon, the sun and the planets	70%	**50%**
How things like mobile telephones, radios, computers and televisions work	70%	**53%**
The car and how it works	65%	**39%**
X-rays and ultrasound in medicine	59%	**54%**
Poisonous plants and mushrooms	59%	**64%**
How the body works	59%	**36%**
How the eye can see	58%	**57%**
Alternative sources of energy: from the sun, from wind etc.	57%	**39%**
Why the dinosaurs died	53%	**68%**
The possible dangers of science and technology	52%	**54%**
Chemical elements and their properties	52%	**32%**

- Topics that 50% or more male participants indicated they wouldn't like to know more about.

Things I wouldn't like to learn more about	Male	Female
Detergents, soaps and how they work	65%	**43%**
Why the sky is blue	59%	**18%**
Famous scientists and their lives	53%	**43%**
How to improve the harvest in gardens, allotments and farms	53%	**32%**
Food processing, conservation and storage	53%	**39%**
How animals like birds and fish navigate	53%	**7%**

- Topics that more than a third female participants indicated they wouldn't like to know more about

Things I wouldn't like to know more about	Female	Male
Electricity, how it is produced and used in the home	50%	**29%**
Detergents, soaps and how they work	43%	**65%**
Alternative sources of energy: from the sun, from the wind etc.	43%	**18%**
Famous scientists and their lives	43%	**53%**
The greenhouse effect and how it might be affected by humans	39%	**41%**
Food processing, conservation and storage	39%	**53%**
How scientists think and work	38%	**35%**

Question 8: What was the most enjoyable thing you have done in a science lesson[35]?

Key Stage 2

- Making flubber
  - 20 of KS2 participants identified making flubber[36] as the most enjoyable thing they had done in a science lesson.
  - One KS3/4 also identified making flubber as the most enjoyable thing she had done in a science lesson.
  - Where participants expanded on their answer, the following comments were made:
    - o When we finished the curriculum for the term, and got to do loads of experiment. We to make 'flubber', a rubbery, stretchy substance.
    - o I think the most enjoyable lesson was making flubber on science morning in class six.

[35] Five participants identified more than one activity
[36] http://www.omsi.edu/visit/playground/activities.cfm

- Volcanoes
    - 5 participants identified making ‘volcanoes’ as the most enjoyable thing they had done in a science lesson.
- One participant expanded on their answer with the comment:
    - Making volcanoes - because it was really hands-on!

- Sorting materials
    - 3 participants identified sorting materials as the most enjoyable thin they had done in a science lesson.
    - One participant expanded on their answer with the comment
        - How to separate lentils, pasta, staples and bulldog clips into each container
- Car ramps
    - 2 participants stated that ‘car ramps’ were the most enjoyable thing they had done in a science lesson.
    - Only 2 participants mentioned other activities – ‘learning about planets’ and ‘the rainforest’.

<u>Key Stage 3/4</u>

- Eight participants identified doing experiments, but with no mention of specific activities, as the most enjoyable thing they had done in a science lesson:
    - Experiments – I enjoy them all!
    - Chemistry experiments. Anything hands on.
    - Practical experiments. When I see the reaction of different gases.
    - Experiments with reactions and finding out what substances cause reactions with others
    - Different explosive experiments
    - Blowing things up and burning stuff
    - Blowing things up

- Seven participants identified specific activities, one of which was making flubber. The other activities were:
    - When we made a pink cemcle tern to lime green by highing it up by a busan berner
    - Hard decision because my science lessons normally very good - it's between exploding an egg disecting a sheep's heart (more interesting than enjoyable!)
    - Make shampoo and explode an egg
    - When we do gas mixed with water, threw in a match - and there was a big explosion.
    - Making hydrogen - and making it 'pop'!
    - Exploding eggs, making shampoo, running around the school to investigate respiration

<u>Questions 9 and 10: Can you think of a famous scientist? Do you know what they were famous for?</u>

<u>Key Stage 2</u>

- 5 participants could think of a famous scientist (4 males and 1 female)
- 4 participants identified Albert Einstein, with 1 identifying Isaac Newton.
- Only 1 participant attempted to identify what Einstein was famous for. They wrote ‘cycling things?’ The participant who identified Newton wrote ‘I think he discovered why the sky was blue’.
- A further participant identified Bon Jovi as a famous scientist.

<u>Key Stage 3/4</u>

- 14 participants could think of a famous scientist. 2 participants identified 2 famous scientists.

- 5 participants identified Albert Einstein. 4 participants attempted to identify what he was famous for:
    - Einstein did a lot with chemicals
    - Em2?
    - He did stuff about time and space
    - E=mc2
- 4 participants identified Isaac Newton. All participants attempted to identify what he was famous for:
    - Discovered gravity
    - Discovering gravity
    - Created the theories of gravity, created many opportunities and broadened peoples thoughts on why things fell from the sky!
    - Discovered gravity (didn't invent it!)
- 3 participants identified Marie Curie. All participants attempted to identify what she was famous for:
    - Radioactivity
    - Discovered polonium and radium. She received several Nobel awards. She mainly was known for her discovery of radiation.
    - I think radioactivity
- Other famous scientists identified were:
    - Charles Darwin -the theory of evolution
    - The man in a wheel chair with a voise box -Not sure, all I know is that he is very clever
    - The person (man) who discovered x-rays (but not the dangers originally).
    - Mr Bunsun - He is famous for creating the bunsun
    - Eddison - invented the light bulb

Question 11: Important for your future job?

- Aspects of their future job girls stated were important/not important

	Important	%	Not Important	%
Have an exciting job	**27**	(96%)	**0**	(0%)
Developing new knowledge and skills	**21**	(75%)	**2**	(7%)
Use my talents or abilities	**19**	(68%)	**3**	(11%)
Get a secure job	**19**	(68%)	**1**	(4%)
Make my own decisions	**18**	(64%)	**1**	(4%)
Help other people	**18**	(64%)	**1**	(4%)
Earn lots of money	**15**	(56%)	**3**	(11%)
Have more time for my family	**13**	(46%)	**1**	(4%)
Have more time for interests/hobbies	**13**	(46%)	**3**	(11%)
Work with people instead of things	**11**	(39%)	**4**	(14%)
Have more time for my own friends	**11**	(39%)	**3**	(11%)
Make and invent new things	**11**	(39%)	**8**	(29%)
Become famous	**7**	(25%)	**8**	(29%)
Have an easy and simple job	**5**	(17%)	**12**	(43%)
Control other people	**2**	(7%)	**20**	(71%)

- Aspects of their future jobs boys thought were important/not important

	Important	%	Not important	%
Have more time for my family	**15**	(88%)	**0**	(0%)
Have an exciting job	**14**	(82%)	**0**	(0%)
Developing new knowledge and skills	**14**	(82%)	**1**	(6%)
Earn lots of money	**13**	(76%)	**1**	(6%)
Get a secure job	**13**	(76%)	**0**	(0%)
Use my own talents and abilities	**12**	(71%)	**2**	(12%)
Have more time for interests/hobbies	**12**	(71%)	**0**	(0%)
Have more time for my own friends	**11**	(64%)	**1**	(6%)
Make my own decisions	**11**	(64%)	**1**	(6%)
Make and invent new things	**11**	(64%)	**2**	(12%)
Help other people	**11**	(64%)	**0**	(0%)
Have an easy and simple job	**9**	(52%)	**5**	(29%)
Become famous	**8**	(47%)	**2**	(12%)
Work with people instead of things	**6**	(35%)	**4**	(24%)
Control other people	**6**	(35%)	**7**	(41%)

<u>Question 12: What are your three favourite programmes?</u>

See Section 3.2.2 for discussion.

<u>Question 13 and 14: Can you remember watching a programme that was about science, or that contained a scientist? What was the programme called? What was it about? What did the scientist look like and what were they doing?</u>

See Section 3.2.2 for discussion.

Question 15: How often do you usually watch TV?

	KS2	KS3	Total
Everyday	16	8	24
Most days, but not everyday	12	6	18
A few days a week	2	1	3

Question 16: Rules about watching TV

Two rules mentioned in the question received no responses. These were:

- I am not allowed to watch TV in other people's homes
- No, I don't watch TV at home

	KS2	KS3/4	Total
I'm only allowed to watch a certain amount of television	7	8	15
I'm only allowed to watch certain programmes	8	5	13
I can only watch at a certain time	2	4	6
I can't watch TV before breakfast	11	6	17
When I have finished my homework	18	9	27
It has to be turned off at mealtimes	12	5	17
When I have finished special jobs or things like music practice	9	5	14
No, I can watch anything I like	18	3	21

Question 17: Where do you mostly watch TV in your home

	KS2	KS3/4	Total
In the lounge	24	13	37
In the family room	2	3	5
In the kitchen	2	0	2
In own bedroom	4	3	7
In parents' bedroom	0	1	0

The final question in this section asked the question 'it is now possible to watch some TV programmes on your computer by connecting to the internet. Please put a tick in the box if you have ever watched TV this way?' Thirty one participants responded that they did, with three adding that they only watched clips.

Appendix V
Carousel activity: details of worksheets

Identifying programmes

The programmes included in the worksheets were:

Key Stage 2	Key Stage 3/4
Arthur	Arthur
Blue Peter	Blue Peter
Ace Teens on Machines	Futurama
Franklin	My Parents are Aliens
Engineering at the Cutting Edge	Engineering at the Cutting Edge
Harry and his Bucket Full of Dinosaurs	Sonic X
House of Mouse	Scooby Doo
Newsround	Newsround
Spongebob Squarepants	Spongebob Squarepants
Rewriting History	Rewriting History

Identifying characters

The characters included in the worksheets were:

Key Stage 2	Key Stage 3/4
Blue Peter presenters	Blue Peter presenters
Newsround presenters	Newsround presenters
Michaela Strachan	Michaela Strachan
Lisa Simpson	Lisa Simpson
Auntie Mabel (*Come Outside*)	Amy (*Futurama*)
Doc and his assistant (*Ministry of Madness*)	Atomic Betty
Mad Dad scientist and his son (*Planet Sketch*)	Family from *My Parents are Aliens*

Identifying episodes

The episodes included in the worksheets were the same for both groups of participants:

- *Futurama*: an episode where a character, Fry, wins a tour of a factory where a popular soft drink, ‘Slurm’, is manufactured. The episode provides a pastiche of the film *Charlie and the Chocolate Factory*, with the secret ingredients of ‘Slurm’ being addictive and the factory where it is produced being staffed by ‘grunka lunkas’, characters similar to the ‘oompa loompas’ in the original film.
- *The Simpsons*: following a surprise visit from some nuclear inspectors, after Homer had created a nuclear meltdown when sleeping on the job, Homer is instructed by his employer to go to college to take a course on nuclear physics. He needs to pass the course to keep his job. The episode is a pastiche of National Lampoon's Animal House (a 1978 US-produced film about college life in the early 1960s - reprised more recently in sub-genre films American Pie and Porkies), where Homer tries his best to reprise the anarchic role of the late John Belushi. Homer meets three male physicists - stereotypical "geeks" with few social skills, no sporting ability, glasses, and spots—who try to teach Homer physics while he tries to lead them astray.
- *Spiderman*: an episode featuring a character called Michael Morbius. Morbius, following an outbreak of a virus in his Eastern European (read Transylvanian) village, which he believes has been caused by vampire bats, has come to America to find a cure that he will return with to his home country. Although officially a student at Hardy Foundation Research Centre, where Peter Parker (aka Spiderman) is also a researcher, Morbius is carrying out secret experiments with stolen equipment in a hidden laboratory. As a result of one of these experiments Morbius is turned into a human vampire with super-human powers.
- *Zombie Hotel*: an episode where the children, Maggot, Sam and Fungus, take part in a Science Fair at school. The children have produced a potato clock, which is laughed at by other pupils, especially by two other children whose parents have provided the funds to develop much more sophisticated entries for the competition. Maggot, Sam and Fungus, however, win the competition because they are the only entrants that have followed the competition rules correctly.
- There was also an additional sheet on which the participants could record the details of any episode of a programme they remembered that included science, engineering or mathematics.

Constructing dialogue

The characters included in the worksheets were:

Key Stage 2	Key Stage 3/4
Mr Ratburn (from the programme *Arthur*)	Mr Ratburn (from the programme *Arthur*)
Prof. Farnsworth (from the programme *Futurama*)	Prof. Farnsworth (from the programme *Futurama*)
Captain Scarlett and Lt. Green	Jake (From the programme *American Dragon*)
Ellie Harrison (co-presenter of *Michaela's Challenge*)	Daphne and Velma (from the programme *Scooby Doo*)
Roobarb and Custard	Ben, Reed, Johnny and Susan (the *Fantastic Four*)

Watching extracts

The extracts watched by the participants were:

Key Stage 2	Key Stage 3/4
Newsround: Report on the invention, by Prof. Huosheng Hu, of Robot fish.	*Engineering at the cutting edge:* The design of the Millennium Bridge and overcoming the problems of the bridge swaying when people walked on it
Primary Geography: Science of the wind. Two children learning about the science of wind from 'experts' and from doing some experiments themselves.	*GCSE Bitesize: Physical Geography:* 'soft' and 'hard' engineering solutions to flooding

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2008 Research report Open Uni. (In)visible Witnesses Investigating gendered representations of scientists, technologists, engineers and mathematicians on UK children's television